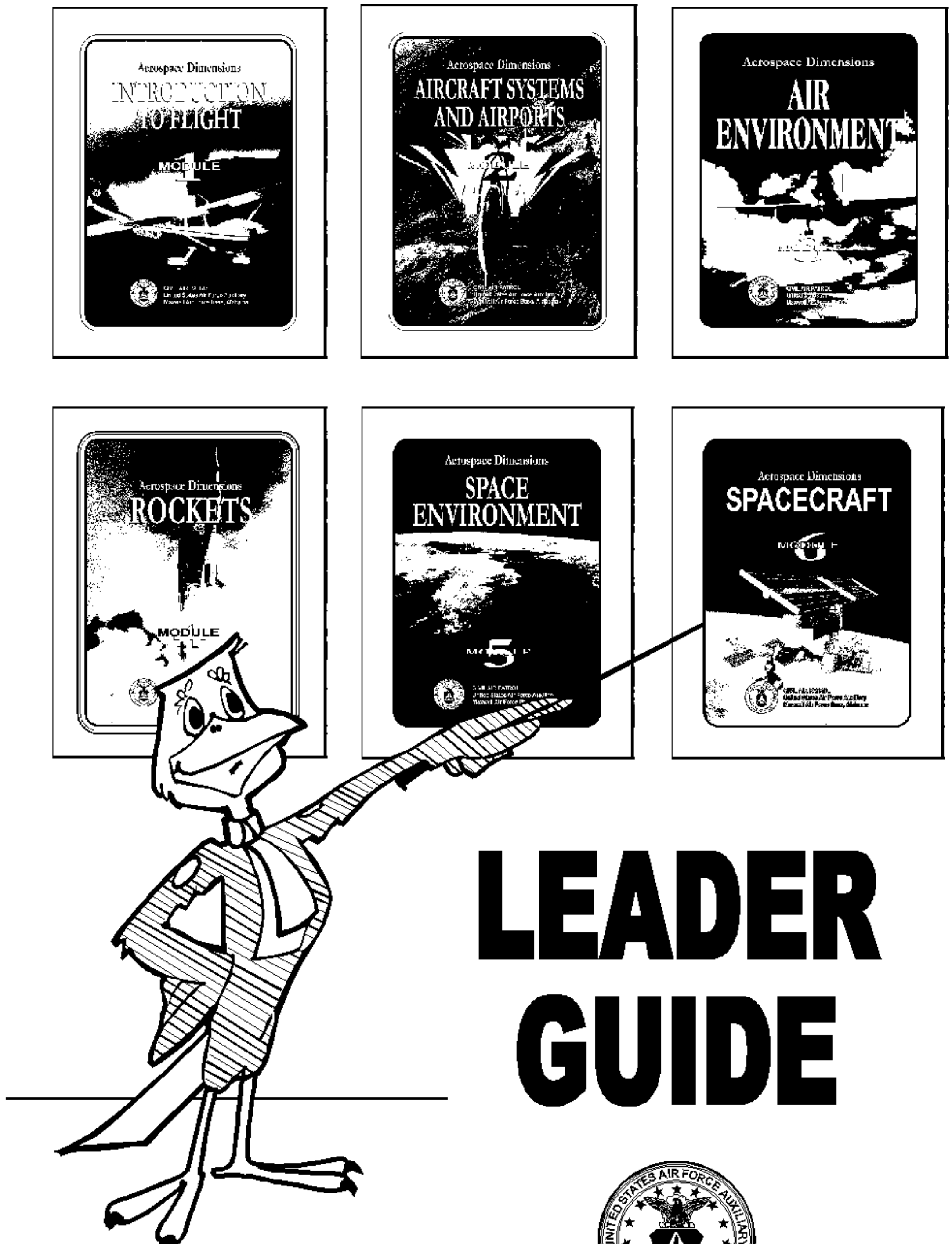

LEADER GUIDE

UNITED STATES AIR FORCE AUXILIARY
CIVIL AIR PATROL

LEADER GUIDE

FOR

AEROSPACE DIMENSIONS

2000

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LEADER GUIDES
for
AEROSPACE DIMENSIONS

Introduction

A *Leader Guide* has been provided for each lesson in each module of Phases I and II**,** ***Aerospace Dimensions***. These guides suggest possible ways of presenting the material to the cadets and are for the leader's use. However, how you proceed is up to you.

There will always be several different ways to present a lesson, and another way may be as good or better than what we provided. If you have other ideas, please use the method or information you think will ensure the material gets to the cadets. Regardless of how the lesson is presented, the important point is that the learning outcomes are covered. The learning outcomes are the information the cadets should learn, and the knowledge they should take with them from the particular lesson. We included these learning outcomes with each lesson. After the lesson, cadets should be able to answer questions about the outcomes on a test.

Our new aerospace education program encourages participation. We included several activities with each module. We hope you will lead the cadets in these activities. We suggest that the activities be done in small groups rather than cadets working alone. Having cadets work together is one of our overall goals. These activities are meant to help accomplish that goal.

Another of our goals is to have fun with aerospace education through the Mitchell award. Again, we hope these activities will facilitate enjoyable group exercises with maximum participation in your squadrons. We also believe that these activities will reinforce the learning from the texts.

With few exceptions, the materials needed for these activities can be found in your home or your cadets' homes. So when you participate in these activities, expenses should not be a problem. The activities are coded for the amount of time needed to perform the activity. The code is: ***** = 15 mins or less, ****** = 15-30 mins, ******* = 30-60 mins, ******** = 60 or more mins. An activities' materials list begins at page 46.

We want leaders to be comfortable with this material. Our lessons were developed with this in mind. If you spend a few minutes with the leader guides and the text information before beginning a lesson, you should be very comfortable with presenting these lessons. This should apply regardless of your prior knowledge of the particular subject.

So, please take a few moments and prepare for the lesson you are going to present. Whether you use our guidance or any other materials, a few moments of preparation goes a long way toward ensuring the lesson's success. This leads to increased knowledge by the cadets; knowledge with which the cadets learn and grow in their educational pursuits in Civil Air Patrol.

On behalf of the education and training staff of National Headquarters Civil Air Patrol, we wish you much success with your lessons, and hope you and the cadets have fun!

CONTENTS

LEADER GUIDE
for
MODULE ONE

INTRODUCTION TO FLIGHT

Chapter One—Flight

Learning Outcomes--Upon completion of this chapter, the cadet should know:

- The relationship between Bernoulli's Principle, Newton's three laws of motion and how they were used to develop a machine that could fly.
- The coefficient of lift and the parameters involved.
- The parts of an airplane and an airfoil.
- The four forces affecting an airplane in flight.
- The three axes, movement around those axes and the control surfaces that create the motion.

Important Terms

Aerospace Education - branch of general education concerned with communicating knowledge, skills and attitudes about aerospace activities and the total impact of air and space vehicles upon society
Aerodynamics - relating to the forces of air in motion
Aeronautics - the science of flight within the atmosphere
Air - a mixture of gases that contain approximately 79% nitrogen, 19% oxygen and 2% other gases
Aircraft - any machine that is capable of flying through the air; ex. ultralights, airplanes, gliders, balloons and helicopters
Airplane - an aircraft that is kept aloft by the aerodynamic forces upon its wings and is thrust forward by a propeller, or other means of propulsion, such as a jet or rocket
Airfoil - a component, such as a wing, that is specifically designed to produce lift, thrust or directional stability
Altitude - height expressed in units above sea level, or ground level
Camber - the curved part of an airfoil that goes from the leading to the trailing edge
Chord - a line drawn through an airfoil from its leading to its trailing edge
Drag - a force which retards the forward movement of an aircraft in flight
Dynamic - forces in motion
Leading edge - the front part of an airfoil
Relative wind - the flow of air which moves opposite the flight path of an airplane
Thrust - the force which moves an aircraft forward in flight
Trailing Edge - the back part of an airfoil
Static - standing still, or without motion
Wind - air in motion

PRESENTATION

Attention: What does it mean to fly? Why did early dreamers fail when they tried to emulate the birds? Make a connection between Bernoulli's principle and actual flight. Make a connection between Newton's three laws of motion and actual flight. Explain the word *force* in terms other than flight. What are the four forces acting upon an airplane in flight? Discuss the forces acting upon vehicles other than an airplane; like a roller coaster, or an automobile, and then compare those to an airplane. Give an example of an axis other than those used in the study of airplanes.

Motivation: Understanding the background and principles involved in flight will help the cadet get more out of and appreciate an orientation flight. Once a cadet understands the vocabulary and principles of flight, he/she will feel much more comfortable around pilots and "airplane people."

Overview: The Wright brothers were successful because they developed an understanding of how a machine can harness the energy of the environment. They used a scientific method of testing their theories and this led to controlling the machine during sustained, gliding flights. By adding power, the brothers then refined their machine so they could repeat their findings again and again. This was putting science to work and that is known as technology.

The AEO should use this example of the Wright brothers, and the explanations within the text to give the students a clear understanding of what a flying machine is and how it works. By weaving in the historical and the technical, the cadet should be able to gain an appreciation for the rich heritage and incredible scientific significance of controlled, sustained and powered flight.

Lesson Outline:

1. Go over the ***Important Terms*** and explain them as a "new language."
2. Develop the history of man's quest to fly.
    a. Introduce Icarus and his fatal effort to fly to freedom.
    b. Introduce man's first powered flight in a balloon
3. Nature's flying machine—Discuss bird flight.
4. Introduce Bernoulli and Newton as great scientists and how their principles and laws laid the groundwork for the science of flight.

Activity One* Demonstrate, and let the cadets follow, how to make a piece of paper lift by blowing over the top.

Activity Two* Use the hair dryer and demonstrate "Is Bernoulli's Principle Worth Two Cents?"

5. Discuss the Coefficient of Lift, not from a mathematical standpoint, rather from what parameters are involved. Point out that the aeronautical engineer has to use several "bits" of information to determine how much lift a wing will produce.
6. Using a "regular" airfoil, have the cadets discuss how (1) making a wing larger; (2) making the camber more curved; (3) making the wing go faster; (4) or how increasing the angle of attack, .will create more lift

7. Using a model airplane, preferably a high wing monoplane similar to a Cessna 172, discuss the parts of an airplane and its wing.

Activity Three* Use the soda straws to demonstrate the three axes.
Activity Four** Make a paper airplane and fly it around.
Activity Five*** Assemble an SR71 and fly it.

Answer to Review Questions: 1 d; 2 d; 3 a; 4 c; 5 b; 6 a

Chapter Two—To Fly By The Lifting Power Of Rising Air

Learning Outcomes—Upon completion of this chapter, the cadet should know:

- How gliders use the environment to obtain altitude.
- Why gliders look differently than powered airplanes.
- How gliders can achieve great distances without power.

IMPORTANT TERMS

Altitude - the height or distance above a reference plane. The most common planes of reference used in aviation are heights above sea level and ground level. If it is above average sea level, it is referred to as “MSL”, or Mean Sea Level, and if it is Above Ground Level, it is referred to as “AGL”.
Aspect Ratio - the ratio between the span of the wing and the chord length
Glide Ratio - a mathematical relationship between the distance an aircraft will glide forward to the altitude loss. If an aircraft has a glide ratio of 20 to one, and it is one mile above the Earth, it should glide 20 miles before landing.
Lift to Drag Ratio - this ratio is used to measure the gliding efficiency of an aircraft. The angle of attack that results in the least drag will give the maximum lift to drag ratio, the best glide angle and the maximum glide distance.
Stability - the atmosphere’s resistance to vertical motion
Thermal - a column of air that moves upward
Tow Plane – usually a single-engine airplane that will pull a glider from the ground to an altitude where it can be released

PRESENTATION

Attention: How does the Sun affect the soaring conditions within the environment. Do gliders often fly at night? Why? How is the atmosphere different at10,000 feet, 25,000 feet; 50,000 feet? Why do gliders have such long wings?

Motivation: There are glider encampments available for Civil Air Patrol cadets. One of the first flight opportunities for Air Force Academy cadets is the glider program. Student pilots can solo a glider as early as age 14. Model gliders are fun to build and if cadets want to take it one step further, it is a very rewarding hobby.

Lesson Outline:

1. Go over the ***Important Terms*** and explain them as a new language.
2. Develop the history of man's attempts to fly and how gliders were the first aircraft built by the Wright Brothers.
3. Go over the components of the glider and then compare those to the actual powered airplane shown in Chapter One.
4. Explain the mathematics of glide ratio. You may also use a paper airplane to deter mine its glider ratio.

Activity One—Build An Air Force Academy Glider*** This is an outstanding cadet activity and requires only a few tools and supplies: For 30 cadets, you will need 60 foam meat trays. To bond the foam parts, you will need about 6 hot glue guns and 3 extra glue gun slugs. To cut the foam, it suggested that the squadron buy a set of 30 utility knives that have "snap" blades.

Answer to Review Questions: 1 a; 2 c; 3 d; 4 a; 5 c; 6 c

Chapter Three—Balloons, They Create Their Own Thermals

Learning Outcomes—Upon completion of this chapter, the cadet should know:
- The principle of buoyancy and how this relates to the flight of a balloon.
- The components of a balloon and how each works in the flight profile.
- The history of the balloon and why it's recognized as the first powered manned flight.

Important Terms

Buoyancy - to rise or float on the surface of water or within the atmosphere
Burner - the heat source for filling the envelope with hot air
Envelope - the main body of the balloon usually made of nylon
Montgolfier - the name of the two French brothers who created the first successful manned hot air balloon in 1783
Propane - a lightweight, low carbon fuel used in hot air balloon burners
Wicker - a form of wooden construction used in the baskets (gondolas)

PRESENTATION

Attention: Discuss the statement, " a hot air balloon creates its own thermal. Discuss the shape of a balloon and why it looks so much different from other aircraft. Explain the reason why propane is used as opposed to natural gas, kerosene or even gasoline as a fuel for the burner.
Discuss the various means that a balloon pilot has to control the direction of the flight of a balloon.

Motivation: A balloon, more than any other aircraft, has a very romantic heritage. Tell the cadets about the champagne "brunch" that follows most balloons flights and why one of the most spectacular events in aerospace is the annual **Balloon Festival** in Albuquerque, New Mexico. Consider having the cadets research this event on the Internet or at a library.

There are several outstanding videos about the Balloon Festival that could be shown to the squadron.

Overview: The Wright's weren't the only famous "brothers" in the heritage of aerospace. Two French brothers built the first powered, manned aircraft in the 18th Century. The hot air balloon is a spectacular site and it is not only a marvel to see in flight, it proves that "old" can be as exciting as "new" technology. A balloon is one aircraft where a cloud can come right into the "cockpit" with the pilot and the in flight view is almost a religious experience to many balloonists!

Lesson Outline:

1. Go over the ***Important Terms*** first so cadets will understand how to speak the language of balloons.
2. Develop the history of the Montgolfiers and their contribution to aerospace.
3. Introduce the principle of buoyancy as a science.
4. Study the structure of a balloon and discuss how its technology was developed over two centuries.
5. Develop an understanding of how a balloon is **controlled.**
6. Introduce the mathematics of the lifting power of lighter-than-air gases.

Activity recommendation*** It is highly recommended that the squadron aerospace education officer call the Civil Air Patrol Supply Depot and discuss the costs of building and launching a hot air balloon kit. These kits are usually less than $10 and can be built as a squadron project. With a small burner, they can be launched indoors or outdoors, depending upon weather conditions. The CAP Supply Depot's toll-free number is (1-800) 858-4370.

Answer to Review Questions: 1 b; 2 d; 3 d; 4 b; 5 c; 6 b

LEADER GUIDE
for
MODULE TWO

AIRCRAFT SYSTEMS & AIRPORTS

Chapter One—Airplane Systems

Learning Outcomes—Upon completion of this chapter, the cadet should know:

- How a reciprocating aircraft engine operates.
- Be able to recognize parts of the engine when viewed externally.
- How a jet engine operates.
- The basic cockpit-mounted power plant controls.
- The basic flight instruments.

Important Terms

Combustion - the chemical process of burning
Compression - the act of making a given volume of gas smaller
Cycle - a recurring series of events. The airplane engine has four cycles, intake, compression, power and exhaust.
Fuel - a chemical substance that is used as a source of energy. Aircraft fuels include gasoline, kerosene and propane.
Reciprocating - a type of engine that processes air and fuel by a back and forth movement of its internal parts
Stroke in the example of an airplane engine, it is the movement of the piston, within the combustion chamber to its limits

PRESENTATION

Attention: The cadet should know how the Sun's energy was first stored in ancient plants and animals. Over millions of years, their remains were converted to fossil fuels. That stored energy is now being converted to mechanical energy by both reciprocal and jet engines. An interesting discussion can be started with this point: Since propane is a by-product of fossil fuels, would it be considered an "aircraft fuel" as it is used in hot air balloons. Another would be Helium. Since Helium is found in natural gas fields, could it be considered a "fossil fuel" for airships?

Motivation: Many of the early experimenters had limited success building and testing gliders. In the later part of the 19th Century, pioneers like Chanute and Lilienthal even developed some control of their gliding flights. The Wright brothers developed a sophisticated method of controlling their gliders and eventually they added a primitive engine. This gave them controlled, **powered** and sustained flight. It was the combination of these three achievements that gave them a place in history as the first to fly a successful airplane.

Overview: The Wright brothers were successful because they developed an understanding of how a flying machine can harness some of the energy of the environment. They used a scientific method of testing their theories and this led to controlling the machine during sustained, gliding flights. **By adding power, the Wright brothers had a machine that could repeat their flights again and again**. Putting science to work for the betterment of mankind is known as technology.

Lesson Outline:

1. Go over the aircraft engine components and show the cadets how each component is related to converting energy into thrust.
2. If at all possible, take the cadets to an aircraft repair facility to show them an engine with the cylinder head removed. Using the text, have students identify the components.
3. Have the cadets converse with a mechanic so they can begin to understand the language of the *Important Terms*.

Activity One*** As suggested, build an activity around a field experience with an actual aircraft engine.
Activity Two* It is recommended that the AEO pick up a toy gyroscope at a toy, crafts or hobby store and demonstrate it as it would be an artificial horizon or as a heading indicator.

Answer to Review Questions: 1 d. 2 b. 3 c. 4 b. 5 d. 6 c.

Chapter Two—Airports

Learning Outcomes—Upon completion of this chapter, the cadet should know:

- The basic layout of a general aviation airport.
- The taxiway and runway signs and markings.
- The role of the Federal Aviation Administration in controlling air traffic.
- The flight profile.
- The phonetic alphabet.

Important Terms

ATC - Air Traffic Control
Controlled Airport - an airport with an operating control tower
Course - the intended path of flight. This is measured in angular degrees from true or magnetic north.
Heading - the direction that an airplane points with respect to true, or magnetic north, including any wind displacement. The direction of the airplane is based on its longitudinal axis.
Ramp - the airport's "parking lot"
Runway - a dedicated pathway for taking off and landing airplanes

Taxiway - a passageway between the parking area and the runways of an airport

PRESENTATION

Attention: Airplanes are very expensive and they are very fast! The cadets must be made aware of the importance of regulations and an orderly flow of air traffic. In order to provide safe operation and a system that works for everyone, the Federal Aviation Administration has strict rules and procedures for everything from small training planes to large international air carriers and military aircraft.

Motivation:

The CAP cadet has an opportunity to go on orientation flights with senior members. To better understand this flight, it is recommended that Aerospace Education Officers give cadets a thorough briefing on: (1) local airport layout; (2) signs; (3) traffic regulations both on the ground and in the air; (4) the flight profile; and (5) the safe transition of an aircraft from the local airport to the airspace beyond this facility. Understanding these 5 points will make the orientation flights much more interesting and enjoyable.

Overview: An AEO should approach the study of an airport from the standpoint of it being a "home" for airplanes. Another angle that will interest cadets is the cost comparison between airplanes and expensive automobiles. The conversation becomes quite interesting when they realize that although a Ferrari may cost $150,000, that is quite average for an airplane! Another interesting note is speed. The cadets will be surprised to know that most airplanes are just in a state of transition from ground to flight at the national speed <u>limit</u> for automobiles! Because of these higher speeds, the rules governing airports and air traffic are very strict.

Lesson Outline:

1. Go over the ***Important Terms*** and discuss the role of the Federal Aviation Administration.
2. It is recommended that the AEO, or instructor, use an overhead projector. Color pens work especially well in the explanation of:

    a. Magnetic vs. True
    b. Runway numbers
    c. Runway markings
    d. Runway signs
    e. Traffic patterns
    f. Runway lights.
    g. Wind indicators

3. Give the cadets the phonetic alphabet and then have them try various words.

Activity One** Although not shown in the activities section of this Volume, an AEO might get a long, rectangular piece of cardboard and have the cadets create a "runway" with all the markings. White tape could be used for the stripes, hard candy might be used for "lights" and a control tower, or rotating beacon, could be constructed from stirring sticks and cardboard! It is simple and only requires a little imagination.

Activity Two** One of the most enjoyable activities is the "Final Approach" using a toy plastic airplane, a long piece of fishing line, and a broomstick. This activity was used in the beta test of the cadet textbook and was voted the most fun by the cadets. Study the activity description and then get the supplies necessary. Including the plastic airplane, it costs less than $5.00. This was a successful "simulator" long before computerized flight simulators became popular.

Answer to Review Questions: 1 d. 2 d. 3 b. 4 c. 5 d. 6 a.

Chapter Three—Airport to Airport—Aeronautical Charts

Learning Outcomes—Upon completion of this chapter, the cadet should know:
- The basic layout of the sectional chart
- The sectional chart legend
- How to read latitude and longitude.
- How to find features, such as railroads, pipelines, obstructions and highways.
- How to read all of the information given about an airport.

Important Terms

Chart - a projection, usually on paper, showing a body of land and other features such as water. The chart gives information, usually in the form of symbols, graphs or illustrations.
Latitude - a system of lines that run parallel to the equator, also known as parallels
Longitude - a system of lines, known as meridians, between the north and south poles
Nautical mile - a unit of length that is approximately 6076 feet
Scale - the size of an item, or area, on a chart, compared to it in actuality
Sectional - a chart specifically designed for aviation use and visual flight rules. The scale is 1:500,000 or approximately 8 statute miles to one inch.
Statute Mile - a unit of length that is 5,280 feet

PRESENTATION

Attention: Once a cadet is familiar with the layout and operation of an airport, the next logical step is to go from airport to airport. To fly cross-country, a pilot must be familiar with maps so that he or she won't become lost along the route of flight. Student pilots are introduced to sectional charts and these provide a great amount of information that will be helpful to them when they leave the familiar vicinity of the home airport. CAP cadets can learn a great deal about the science of cartography by studying aeronautical charts.

Motivation:

Once the cadet learns the legend of a sectional, it is a very rewarding experience to apply this knowledge to the chart. Then, a cadet can take a sectional along on an orientation flight and discover how the features look from the air. This is an excellence learning experience that has practical applications.

Overview: The cadets should not be threatened by the complexity of a sectional chart. Starting with the legend and then taking a small section at a time, cadets will find the features to be logical and enjoyable.

Once the cadets have a grasp of the very basics of aeronautical charts, it is recommended that senior members, who are pilots, introduce basic dead reckoning navigation.

Lesson Outline:

1. Go over the ***Important Terms.***
2. Using the Wichita Sectional excerpt provided in the text, have the cadets first try to find familiar features and landmarks.
3. Then introduce the legend and work on applying legend information to the actual excerpt.
4. Explain how the legend is a basic "tool," and that slight differences occur between it and the actual sectional. This is also covered in the text.
5. Pick another airport, after having gone over the example of Cherokee, Oklahoma's, and have the cadets work on all of the information available for it.

Activity One** The AEO is encouraged to get a local fixed base operator to help get a relatively current "classroom set" of sectional. These can be used for individualized learning activities.

Answer to Review Questions: 1 d. 2 d. 3 b. 4 c. 5 d. 6 a.

AIR ENVIRONMENT
for
MODULE THREE

AIR ENVIRONMENT

Chapter 1 – Air Circulation

Learning Outcomes
After completing this chapter, you should be able to:
- Describe how the sun heats the Earth.
- Describe the Earth's rotation and revolution, and its effect on the Earth's seasons.
- Explain the various theories of circulation.
- Describe Coriolis Force.
- Define the jet stream.

Important Terms:
autumnal (fall) equinox - on September 22, the sun's direct rays strike the equator resulting in day and night of equal length
Coriolis Force - deflects a freely moving object to the right in the Northern Hemisphere
jet stream - a strong wind that develops at 30,000-35,000 feet and moves as a winding road across the US, generally from the west to the east
radiation - the method by which the sun heats the Earth
revolution - the movement of the Earth revolving around the sun; it takes 365 days
rotation - the Earth rotates on its axis at an angle of 23.5° while it revolves around the sun
summer solstice - when the Sun is at its northernmost point from the equator in the Northern Hemisphere, the day is the longest, usually on June 21st or 22nd
vernal (spring) equinox - on March 21, the sun's direct rays strike the equator resulting in day and night of equal length
winter solstice - when the Sun is the farthest south of the equator and the Northern Hemisphere, the day is the shortest, usually on December 21st or 22nd

Activity Materials:
Activity One - Absorbing Heat - 2 tin cans, 2 thermometers, soil, water and sunlight
Activity Two - Warm Air Rising – paper, pencil (wooden with eraser), scissors, metal thimble, needle, spool (sewing thread), and table lamp
Activity Three - Coriolis Force - a globe and chalk
Activity Four - Global Winds - illustration below, pencil, and colored pencils or markers

PRESENTATION

Attention: What is the fundamental cause of our weather? How does it start? Where does it begin? Weather starts with the sun, with the sun heating the Earth.

Motivation: Understanding the foundations of how and why the air moves goes a long way toward building a sound knowledge about weather. This knowledge can then help you understand and explain a lot of what occurs in weather.

Overview: We are going to take a look at how air begins to move and circulate. This movement gets weather started. Everything in weather occurs after this beginning point. So, let's make sure we understand this major point. Our main subjects for this discussion are:

Lesson Outline:

1. **Solar Heating**
   a. The sun heats the Earth unevenly. Some parts are hotter than others.
   b. Unequal heating causes temperature and pressure differences. These differences create movement of air. Temperature differences mean different molecular make up; different molecules mean different pressure too. Air of cooler temperatures means air of higher pressure. Air of higher pressure flows to air of lower pressure.

Activity One ** - This is one that you can setup and then go do something else. We are just trying to show the difference in absorption between the soil and the water.
Activity Two ** - This is a good way to illustrate that warm air rises. Once this is discovered, ask about how this affects the weather. Warm rising air can lead to cloud formations, which can lead to precipitation and storms. This simple fact about warm air really has an amazing impact on our weather.

2. **Rotation and Revolution**
   a. The Earth revolves around the sun in 365 days. The Earth is rotating on its axis at an angle of 23.5 degrees. The Earth's rotation effects the length of a day, and rotation and revolution effect the seasons of the year. Take a couple of moments and discuss the summer and winter solstices, and the fall and spring equinoxes.
   b. In the Northern Hemisphere, the Earth rotates in a counterclockwise direction. This causes objects moving freely to be deflected to the right of their intended path.

Activity Three * - This is an easy and quick way to show the effects of Coriolis Force. It is important to realize that pilots plan for this when they are flying.

3. **Circulation**
   Circulation refers to the global movement of air. Take a map of the world or a globe and show the different wind patterns in the different parts of the Earth. Talk about the warm air rising from the equator and the cold air moving down from the poles.

Activity Four * - Tie this into the conversation about circulation. Use Columbus' voyage to America as a practical example of the importance of knowing circulation patterns.

Answers to Review Questions: 1. c; 2. c; 3. a; 4. c; 5. a; 6. T; 7. T

Summary

This chapter is very important for understanding some basics about weather. These fundamental principles dictate so much of our weather. The sun does heat the Earth unevenly. Warm air does rise. Rotation and revolution affect our days and seasons. Global wind patterns bring us our weather. These are important basic facts about weather.

Chapter 2 – Weather Elements

Learning Outcomes

After completing this chapter, you should be able to:

- Define wind.
- Describe the Beaufort scale.
- Define heat.
- Explain what temperature is and how it can be expressed.
- Describe what wind chill is and what it does.
- Describe how a microburst can affect a plane.

Important Terms:

atmospheric pressure - the weight of all of the atmosphere's gases and molecules on the Earth's surface
Beaufort Scale - a scale for estimating wind speed, on land or sea
heat - the total energy of all molecules within a substance
microburst - a downdraft or downburst of wind
temperature - a measure of molecular motion expressed on a man-made scale
wind - a body of air in motion
wind chill - temperature and wind speed are used to explain how cold it feels

Activity Materials:
Activity One - Wind Currents - electric fan, stack of different sized books and a strip of tissue paper
Activity Two - Wind Gauge - clear, plastic drinking straw, small styrofoam ball, two pins, Piece of cardboard (about 3x12 inches), transparent tape and exacto knife or scissors
Activity Three - Convert Temperatures - problems are provided
Activity Four - Thermometer - clear glass bottle (pint or quart), cork or stopper with one hole, plastic drinking straw, 3x5 inch card, pencil, water, food coloring, candle, matches, transparent tape, oil and a medicine dropper
Activity Five - Cricket Thermometer - chirping cricket, watch with a second hand and a warm day
Activity Six - How To Make A Barometer - clear glass or jar, a bowl, four paper clips, water and a grease pencil
Activity Seven - Match the Instrument with What It Measures - information provided

PRESENTATION

Attention: Have you ever gone outside on a windy day and wondered how strong the wind was? Most of us have at one time or another.

Motivation: This lesson will give you a good method of determining the strength of the wind, whether on land or sea. This method, the Beaufort scale, will definitely come in handy sooner or later.

Overview: We will take a brief look at how to measure wind speeds and then move into discussions on temperature and pressure.

Lesson Outline:

1. **Wind**
    a. The Beaufort scale has been used since 1805. Take a copy of it outside, unless the winds are calm, and use the scale to discuss the speed of the wind. You are only estimating the speed, but this is a reliable estimation.

Activity One * - This is a quick way to see how air will move up and over mountains. This effects the temperature and the winds.
Activity Two * -** Make your own wind gauge, a nifty thing to have around.

   b. Wind chill - Use the temperature and wind speed to explain how cold it <u>feels</u>. In cold weather, heat escapes from your body, then winds blow the heat away; the stronger the winds, the faster the heat is blown away. Be sure to take a moment and look at a couple of wind chill examples. Cadets need to realize what a difference in temperature the wind can make.
   c. A microburst is a dangerous phenomenon for aircraft. The updrafts and downdrafts cause turbulence, sometimes very heavy turbulence. The strong force of the winds in a microburst causes a pilot to make a correction. Then if the winds suddenly change directions again, it affects the lift of the plane, and the pilot has to react very quickly to recover the aircraft.

2. **Temperature**
    a. Go over the formulas for converting temperature to the different scales. Work a few problems.
    b. Cadets should know the boiling and freezing points of the scales.

Activity Three ** - Convert temperatures to Fahrenheit and Celsius.
Activity Four * -** Make the thermometer, then keep it around and use it from time to time.
Activity Five * - This activity works really well at estimating the temperature; however, you need a warm day and a cricket.

   c. Spend a moment and go over the dangers associated with extreme temperatures; particularly the effects of extreme hot and cold on our bodies.

3. **Atmospheric Pressure**
    a. This is the weight of all of the molecules of all of the gases that makeup the atmosphere; this weight exerts pressure on a given space. Atmospheric pressure is

strongest near the Earth's surface and decreases with height.

b. Atmospheric pressure instruments: aneroid barometer - hangs on the wall and is easy to read; aneroid barograph - a graph that gives a permanent record of the pressure; mercurial barometer - most accurate, but not quick or easy to read.

Activity Six * - Once you have the barometer setup, refer to it often and check to see if the water is rising or lowering.

Activity Seven * - You can do this verbally or use a chalkboard. It's good for review purposes. Answers: rain gauge = precipitation, barometer = air pressure, wind gauge = wind speed, and thermometer = temperature.

c. Take a moment and discuss pressure changes and its effects on our sinuses and our ears.

Answers to Review Questions: 1. b; 2. c; 3. c; 4. a; 5. b

Summary

This chapter discussed wind, temperature and pressure, three basics in any study of weather. Knowing a little about each of these subjects gives you a good foundation of weather knowledge. These three topics are also of concern to every pilot. Pilots always get a weather briefing before they are cleared for takeoff.

Chapter 3 - Moisture and Clouds

Learning Outcomes

After completing this chapter, you should be able to:

- Describe the condensation process.
- Describe how saturation occurs.
- Define dew point.
- Define what precipitation is and give some examples.
- Define fog.
- Describe relative humidity.
- Define turbulence.

Important Terms:

condensation - the process of converting water vapor to liquid
dew point - the temperature at which the air becomes saturated
fog - tiny droplets of liquid water in contact with the surface
precipitation - general term given to various types of condensed water vapor
relative humidity - amount of water vapor in the air compared to its water vapor capacity at a given temperature
saturation - a parcel of air is holding as much water vapor as it can
turbulence - an unrest or disturbance of air

Activity Materials:
Activity One - Comfort and Humidity - plastic bag or empty bread wrapper, tape and water at room temperature
Activity Two - Dew Point - tin can, thermometer, tablespoon, ice cubes, paper towel, bowl, cool water and salt
Activity Three - Making Fog - clear glass jar, tea strainer, ice cubes and hot water
Activity Four - Cloud in a Bottle - glass jug with a small mouth and a match or candle
Activity Five - Making a Rain Gauge - a 1 lb. Coffee can, olive jar, ruler, marking pen, water, funnel and a watch

PRESENTATION

Attention: How do clouds form? Where do they come from? Clouds are one of weather's most fascinating phenomena, yet one that we take for granted.

Motivation: I'm sure that just about everyone, at one time or another, has asked themselves these questions. If you still don't know the answers, you will learn during this lesson.

Overview: In this lesson, we will talk about how clouds form, and the processes they go through to exist in the sky. We will also discuss other weather phenomena that also stem from these processes. Here is how we will proceed:

Lesson Outline:

1. **Moisture Processes**
    a. Moisture is the single most important element in weather, and it impacts in many ways (clouds, rain, storms). Water vapor is moisture in its gaseous state. It is always present.
    b. Saturation - When air is holding as much water vapor as it can, it reaches saturation. It then has 100% relative humidity.
    c. Condensation - After saturation is reached, if air receives any more water it condenses into liquid form. From a gas (water vapor) to a liquid is condensation. Clouds, fog and rain are all products of condensation.

Activity One * - This activity is a fast way to see what humidity can do to your comfort level.
Activity Two ** - A good way to talk about what temperature and dew point really are. Dew point is frequently misunderstood. It is a concept worth understanding; it helps saturation and humidity make sense.
Activity Three * - It is good to see how easy fog can form with the moisture. It is a good time to talk about the hazards surrounding fog, like driving a car, or trying to land a plane.

2. **Clouds**
    a. Clouds – Clouds are a combination of tiny droplets of water or ice crystals clinging onto condensation nuclei. Condensation nuclei are tiny particles of salt, soot and dust that are floating around in the air traveling with the winds. As cadets progress

through aerospace education, they will learn a lot more about clouds, but for now, we'll mention the three basic types of clouds. Cadets should know the differences in appearance between the three types. Many people refer to clouds as the signposts of weather. The more you know about clouds the more you can predict future weather. **Cumulus** - puffy, white clouds of fair weather; **Stratus** - thin, flat, sheet-like, gray clouds; **Cirrus** - very high wispy clouds.

Activity Four * - For this activity, be careful with the match and don't breathe in the smoke. Be sure the mouth of the jug is not too hot before you put your lips on it. Cadets may have done this activity before, it is an oft-repeated exercise in many science classes.

b. Precipitation is another product of condensation. It is the general term used for the types of condensed water vapor that fall to the earth's surface. Precipitation falls as liquid (rain or drizzle), frozen (snow or hail), or partly-frozen (ice or freezing rain).

Activity Five ** - This is a great exercise for keeping an accurate account of how much rain is falling or has fallen. Once you've made your rain gauge, you can use it whenever you want. It is standard practice to measure rainfall for an hour, 6 hours, or even a day or month. It is important to remember to record your measurements and then dump out the rain so that it doesn't get counted again.

Answers to Review Questions: 1. d; 2. b; 3. a; 4. a; 5. F; 6. T

Summary

The weather processes that involve moisture are among the most important for understanding basic weather information. These processes, such as saturation and condensation, explain much of what happens in weather. Clouds, fog and precipitation are all products of condensation.

It is always important to remember that weather can tremendously impact flying, and it helps to know the ways in which this happens. As you progress through aerospace education, you will learn more and more about weather's impact on flying.

Chapter 4 - Weather Systems and Changes

Learning Outcomes

At the end of this chapter, cadets should be able to:

- Define an air mass and identify air mass characteristics.
- Define a front and describe the types of fronts.
- Describe hurricanes, thunderstorms and tornadoes.
- Identify the stages of a thunderstorm.
- Outline safety precautions for thunderstorms and tornadoes.

Important Terms:
air mass - huge body of air with the same temperature and moisture characteristics
front - a boundary between two air masses
hurricane - a tropical cyclone of low pressure and very strong winds; usually heavy rain with possible thunderstorms and tornadoes
thunderstorm - cumulonimbus cloud possessing thunder and lightning; usually strong winds, rain and sometimes hail
tornado - whirling funnel of air of very low pressure and very strong winds; can suck up anything in its path and must touch the ground to be called a tornado

Activity Materials:
Activity One - Air Masses - map and matching questions are provided
Activity Two - Identifying Fronts - map and questions provided
Activity Three - Fronts on Maps - map and questions provided
Activity Four - Distance to a Storm - a watch or clock with second hand and a thunderstorm
Activity Five - Matching Severe Weather - questions provided

PRESENTATION

Attention: Do you know what a tornado is? What it looks like? Do you know what to do if you see one?

Motivation: In this lesson, we will not only discuss tornadoes, hurricanes and thunderstorms, but also talk about what to do when they appear. This lesson will be very practical and can help you cope with severe weather situations.

Overview: Before we begin with the severe weather phenomena, we will talk about air masses and fronts. Here is how we will progress:

Lesson Outline:

1. **Air Masses and Fronts**
    a. Air mass - huge body of air with the same temperature and moisture characteristics; as it travels, it carries its characteristics with it.
    b. Source regions - where an air mass originates.

Activity One * - This is mainly a teaching and review exercise. Be sure you use the map and discuss where the air masses are. Have the cadets think about the air mass locations in broad terms. For instance, are the polar and arctic air masses where you would expect them to be? Same thing applies for tropical, and then for maritime and continental. **Answers:** 1. d; 2. a; 3. c; 4. b

    c. Fronts – A front is a boundary or zone between air masses. As an air mass moves, it eventually encounters air of significantly different characteristics. When this happens, the different air masses clash. Take a moment and diagram the various fronts. Be sure the cadets know the differences between them.

Activity Two * - Use this exercise to review fronts. The important aspect to understand is which air is replacing, or pushing or lifting which air. In other words, the relative temperatures of the clashing air masses are important. For example, is warm air replacing cool air? Or, is cold air replacing warm air? **Answers:** 1. b; 2. a; 3. d
Activity Three * - This is a worthwhile, quick exercise in reading maps or map analysis. Knowing what fronts look like on a map can greatly aid a cadet's own forecasting skills. **Answers:** 1. a; 2. c; 3. b

2. **Severe Weather**
   a. **Thunderstorms -** cumulonimbus clouds that always possess thunder and lightning. Cumulonimbus clouds are cumulus clouds with very strong vertical development. **You may not always see the lightning or hear the thunder, but they are present with every thunderstorm.** This is a good point to drill home to your cadets. Many folks believe thunderstorms are much safer than they really are, just because they haven't seen or heard the lightning or thunder. Mention some of the facts from the text: how often they occur, how often lightning strikes, and averages on deaths and injuries. Be sure to go over the safety rules to follow regarding thunderstorms. Just recently, the news mentioned that a teenager died while on the telephone, in his house, during a thunderstorm.

Activity Four ** - This activity provides an excellent method for estimating the distances of thunderstorms in your local area. Repeat this procedure a few times to see which way the storm is moving. **Be careful** how you do this! Maybe stand at a door or in a hallway with a door open. If the storm is really close, like within a mile or so, <u>don't</u> stand outside in the open. **Keep the safety rules in mind**!

   b. **Tornadoes –** A tornado is a very destructive storm consisting of unstable air of very low pressure. Most tornadoes move in a counterclockwise manner, but they are very unpredictable. A tornado is a twisting, turning funnel of air being sucked into its center. Tornadoes drop down out of clouds and move across the ground for a few hundred feet or for several miles, then swoop back up into the clouds. A tornado can drop back down again at any time and generally does. Tornadoes average about 70 mph on the ground and winds can be as high as 300 knots. **Tornadoes are dangerous and destructive!** Please go over the Fujita Wind Damage Scale and the safety rules. Also, this is a good time to talk about personal experiences. There are probably several cadets who have tornado stories to tell!
   c. **Hurricanes -** Tropical storms that form over large bodies of water that move, build and pickup speed and strength are called hurricanes. Hurricanes can be hundreds of miles wide and contain both thunderstorms and tornadoes within them. They wreck havoc with their strong winds, but most of the damage comes from the tidal waves and the tremendous amount of rain and flooding. A very distinctive feature of every hurricane is the **eye**. The eye is its center which consists of calm or almost calm winds and clear skies. As the eye passes, it represents the proverbial "calm of the storm." However, after it passes, the winds blow just as strong and the storm resumes its fury.

Activity Five ** - This activity can be used as a good review for the severe weather section. You can take as much or as little time as you feel necessary.

Answers: 1. d; 2. f; 3. b; 4. i; 5. h; 6. a

Answers to Review Questions: 1. c; 2. b; 3. a; 4. b; 5. c; 6. d; 7. c

Summary

This chapter covered some very important and dangerous aspects of weather. From a practical standpoint, the best summary would probably be reviewing the safety rules of each of the severe weather phenomena. Understanding that these phenomena should not be taken lightly is worth remembering.

LEADER GUIDE
for
MODULE FOUR

ROCKETS

Chapter 1 - History of Rockets

Learning Outcomes
After completing this chapter, you should be able to:
- Identify some of the historical facts about the Greeks, Chinese, and British, and their roles in the development of rockets.
- Describe America's early contributions to the development of rockets.
- List the early artificial and manned rocket launches and their missions.

Important Terms:
Neil Armstrong - first man to walk on the moon
Roger Bacon - increased the range of rockets
Wernher von Braun - director of the V-2 rocket project
William Congreve - designed rockets for military use
Jean Froissart - improved the accuracy of rockets by launching them through tubes
John Glenn - first American to orbit the Earth
Robert Goddard - experimented with solid and liquid propellant rockets; known as the "Father of Modern Rocketry"
William Hale - developed spin stabilization
Hero - developed first rocket engine
Sir Isaac Newton - laid scientific foundation for modern rocketry with his laws of motion
Hermann Oberth - space pioneer; wrote a book about rocket travel into outer space
Alan Shepard - first American in space
Skylab - first US space station
Space Shuttle - a space transportation system for traveling to space and back to Earth
Sputnik I - first artificial satellite
Konstantin Tsiolkovsky - proposed the use of rockets for space exploration.

Activity Materials:
Activity One - The Hero Engine - empty soda can, medium sized nail, string, bucket or tub of water and a hammer
Activity Two - Making A Congreve Rocket - paper, cellophane tape, scissors, sharpened pencil and a straw (slightly thinner than the pencil)
Activity Three - Balloon Staging – two long party balloons, nylon monofilament fishing line (any weight), two plastic straws (milkshake size), styrofoam coffee cup, masking tape, scissors and two spring clothespins
Reference: Remind cadets about the Model Rocketry Program and badge. Refer them to CAPM 50-20 for information on the program and on earning the rocket badge.

SAFETY – Particularly with this module, please remember **SAFETY** at all times.

PRESENTATION

Attention: Who was the first man on the moon? What was the date? Many of us can answer these questions. These are events in recent history. However, hundreds of years of research and experimentation occurred in order for man to walk on the moon.

Motivation: In order to really appreciate what Neil Armstrong did, we need to go back through history and review some of what led to this monumental event. This additional knowledge will give us a foundation on which to build.

Overview: This first chapter in *Rockets* will give us the opportunity to look back at the beginning of rockets and get an idea of how the knowledge and technology progressed over the years.

Lesson Outline:

1. **History**
   a. Greek named Hero developed the first rocket engine.

Activity One ** - This replicates the very first rocket engine, the Hero. It demonstrates the thrust and the resulting spin of the can. This activity demonstrates Newton's third law of motion by using the force of falling water to cause a soda can to spin. The water streaming out of the holes causes the can to spin. You can use this activity to experiment with different ways of increasing the spinning of the can. Have your cadets analyze the relationship between the size of the holes and the number of rotations of the can.

   b. The Chinese developed gunpowder and used it as fireworks and with arrows. These arrows of flying fire were a simple form of a solid-propellant rocket.
   c. In the 13th-15th centuries, the English increased the range and the French increased the accuracy of these rockets.
   d. In the 18th century, the English designed the rocket for military use.

Activity Two -** This is a quick and easy exercise in making an early rocket. You should do this activity in a room with open floor space. A hallway will work well. This is a good activity for working individually or in twos. Be sure to wear <u>eye protection</u>. Encourage cadets to measure the distances the rockets travel and to try different sized and shaped rockets for maximum distance. Also, try a different number of fins.

2. **Modern Rocketry**
   a. Dr. Robert Goddard - "Father of Modern Rocketry." He gave us major breakthroughs in rocket research, with solid-propellant and liquid-propellant rockets. His liquid-propellant rocket was the forerunner of today's rockets.
   b. Achievements - *Sputnik I* was the first artificial (man-made) satellite launched in October 1957 by the Russians. *Explorer I* was the first U.S. artificial satellite launched in January 1958. In April 1961, Yuri Gagarin became the first person to orbit the Earth. In May 1961, Alan Shepard was the first American in space. In February 1962, John Glenn was first American to orbit the Earth. On July 20, 1969,

Neil Armstrong became the first man to walk on the moon. In 1973, Skylab was the U.S.' first space station.

c. Wernher von Braun, a German scientist, headed up the team that built the V-2 rocket that was used at the end of WWII. After WWII, he and about 120 German scientists came to the US and built rockets for the US.
d. Spacecraft were sent into space by powerful rocket systems called rocket launch vehicles. The Redstone was used for Alan Shepard and the Atlas rocket was used for John Glenn's orbit around Earth.
e. Skylab – was US' first space station.
f. Space Shuttle – a transportation system used for transporting to space and returning back to Earth.

Activity Three * -** This is just a nifty way of demonstrating a multistage rocket. When the lower stage has exhausted its load of propellants, the entire stage drops away, making the upper stages more efficient in reaching higher altitudes. In a typical rocket, the stages are mounted on top of each other. Encourage cadets to try other arrangements, like side-to-side, or even three stages.

Answers to Review Questions: 1. d; 2. b; 3. b; 4. a; 5. c

Summary

Summarize the early accomplishments and review the events from 1957 to the present. You could spend some time comparing how far we have come in the last 40 years to the hundreds of years before.

Chapter 2 - Rocket Principles

Learning Outcomes
After completing this chapter, you should be able to:
- Define acceleration.
- Define inertia.
- Define thrust.
- Describe Newton's First Law of Motion.
- Describe Newton's Second Law of Motion.
- Describe Newton's Third Law of Motion.

Important Terms:
acceleration - the rate of change in velocity with respect to time
inertia - the tendency of an object at rest to stay at rest and an object in motion to stay in motion
thrust - the amount of push used to get the rocket traveling upwards
Newton's First Law of Motion - a body at rest remains at rest and a body in motion tends to stay in motion at a constant velocity unless acted on by an outside force

Newton's Second Law of Motion - the rate of change in the momentum of a body is proportional to the force acting upon the body and is in the direction of the force
Newton's Third Law of Motion - to every action, there is an equal and opposite reaction

Activity Materials:
Activity One - Balloon Rocket - a balloon
Activity Two - Rocket Racer - four pins, styrofoam meat tray, masking tape, flexible straw, scissors, drawing compass, marker pen, small round party balloon, ruler, student sheets (one set per group), 10-meter tape measure or other measuring markers for track (one for whole class)
Activity Three - Law of Inertia - stack of checkers
Activity Four - Two Balloons - two balloons, inflated and tied
Activity Five - Roller Skates and Jug - roller skates and plastic jug of water
Activity Six - Antacid Tablet Race - effervescent antacid tablets (4 per group), two beakers (or glass or plastic jars), tweezers or forceps, scrap paper, watch or clock with second hand, thermometer, eye protection and water (warm and cold)
Activity Seven - Newton Car - wooden block about 10x20x2.5cm, 3 3-inch #10 wood screws (round head), 12 round pencils or short lengths of similar dowel, plastic film canister, assorted materials for filling canister (washers, nuts, etc), 3 rubber bands, cotton string, matches or lighter, eye protection for each cadet, metric beam balance (primer balance), vice, screwdriver and a meter stick

PRESENTATION

Attention: OK, let's have some fun!

Motivation: We are going to perform a few activities which should be fun and will also help us understand Newton's laws of motion. These laws are very important in understanding rocket principles.

Overview: We'll begin with a couple of activities, followed by a discussion on Newton's laws of motion, and end with some more activities to help demonstrate those laws.

Lesson Outline:

Activity One * - Gas in the balloon escapes out of the opening, creating a thrust that propels the balloon in the opposite direction, like a rocket. However, the balloon doesn't have any guiding mechanism, so it flies all over the place.
Activity Two * -** A fun activity where you can race or time these vehicles while using rocket principles. This activity encourages cadets to experiment with ways of increasing the distances the cars travel. A good activity to work in pairs or individually. Work with different shapes and sizes, and even placement of wheels to influence distances. This also represents another way to demonstrate Newton's third law of motion.

1. **Newton's First Law of Motion:** A body at rest remains at rest and a body in motion tends to stay in motion at a constant velocity unless acted on by an outside force. Use the example of a shopping cart and talk about friction.

Activity Three * - An easy illustration of Newton's first law. Again, the friction comes into play as well. Or, you can use the alternative, put a ball in your hand and discuss it.

2. **Newton's Second Law of Motion:** The rate of change in the momentum of a body is proportional to the force acting upon the body and is in the direction of the force. Use the example of the hockey puck.

3. **Newton's Third Law of Motion:** To every action, there is an equal and opposite reaction.

Activity Four * - Demonstrates Newton's third law. This is a good demonstration because you can readily see that the balloons are being compressed.

Activity Five * - Another demonstration of Newton's third law. Again, very straightforward approach to this law. If no one has skates, a skateboard will work just as well.

Activity Six* -** Investigates methods of increasing the power of rocket fuels by manipulating surface area and temperature. Cadets compare the reaction rates of effervescent antacid tablets under different conditions. When rocket propellants burn faster the mass of exhaust gases expelled increases as well as how fast those gases accelerate out of the rocket nozzle. Based on Newton's Second Law of Motion, increasing the efficiency of rocket fuels increases the performance of the rocket. Cadets learn that increasing the surface area of a tablet by crushing it into a powder increases its reaction rate with the water.

Expanding the burning surface increases its burning rate. This increases the amount of gas (mass) and acceleration of the gas as it leaves the rocket engine.

In the second experiment, tablets in warm water react much more quickly than tablets in cold water.

Activity Seven* -** The cadets are testing a slingshot-like device that throws a mass, causing the car to move in the opposite direction. The cadets control many variables; such as the size of the string loop they tie, the placement of the mass on the car, the placement of the dowels and the number of rubber bands. These all influence the results. This activity is an excellent tool for investigating Newton's Second Law of Motion.

Answers to Review Questions: 1. b; 2. a; 3. c; 4. b

Summary

Give a brief review of Newton's Laws of Motion.

Chapter 3 - Rocket Systems and Controls

Lesson Outcomes

At the end of this chapter, cadets should be able to:

Identify the four major systems of a rocket.
Describe the purpose of each of the four major systems of a rocket.
Define payload.

Important Terms:
airframe - the shape of the rocket
control system - steers the rocket and keeps it stable
guidance system - gets the rocket to its destination; the brain of the rocket
payload - what the rocket is carrying
propulsion - everything associated with propelling the rocket
Activity Materials:
Activity One – 3-2-1 Pop – heavy paper (60-110 index stock or construction paper), plastic 35 mm canister, student sheets, cellophane tape, scissors, effervescing antacid tablet, paper towels, water and eye protection
Activity Two - Bottle Rocket - 2-liter plastic soft drink bottles, low-temperature glue guns, poster board, tape, modeling clay, scissors, safety glasses, decals, stickers, marker pens, launch pad from the bottle rocket launcher. Begin saving 2-liter bottles several days or weeks in advance so that you will have enough for your cadets. You also need a bottle rocket launcher to complete this activity.
Activity Three - Altitude Tracking - altitude tracker pattern, altitude calculator pattern, Thread or lightweight string, scrap cardboard or poster board, glue, cellophane tape, small washer, brass paper fastener, scissors, razor blade knife and cutting surface, meter stick or metric, rocket and launcher
Activity Four - Goddard Rocket - 14” length of 1 –3/4” outside diameter foam pipe insulation, a foam meat tray for fin templates, #64 rubber band for propulsion, a nylon cable tie to tie the rubber band in the fuselage of the rocket, and a hot glue gun to bond the foam parts together.

PRESENTATION

Attention: We have probably all seen a rocket launch on television, or maybe even in person. What did you notice? What were you thinking? Have you ever wondered how this huge piece of machinery actually gets off the ground and successfully travels into space?

Motivation: This chapter will identify for you the main systems of a rocket. This should help clarify how a rocket actually makes it into space and performs its missions.

Overview: We will take a brief look at the major rocket systems and discuss what these systems actually contribute to the overall operation of a rocket.

Lesson Outline:

Rocket Systems

a. Airframe - Provides the shape of the rocket.
b. Guidance - Gets the rocket to its destination, the “brain” of the rocket.

c. Control - Steers the rocket and keeps it stable.
d. Propulsion - Everything associated with propelling the rocket; includes propellant and engine.

Activity One ** - Fun way to build a rocket and watch it takeoff. For best results, cadets should work in pairs. Be sure to tell the cadets to plan and think before they begin cutting the paper. The rockets can be of various shapes and sizes. Some common mistakes are: forgetting to tape the film canister to the rocket body, failing to mount the canister with the lid end down, and not extending the canister far enough from the paper tube to make snapping the lid easy. This activity demonstrates all three of Newton's laws of motion.
Activity Two ** - Another fun activity of building a rocket. Working in groups will cut back on the needed supplies. For this activity, you need the bottle rocket launcher from the previous activity. Begin saving 2-liter bottles ahead of time. The simplest way to conduct this activity is with low-temperature glue guns. Encourage cadets to decorate their rockets. Create some safety rules and make sure everyone knows and follows them. Safety should include how far everyone stands from the launch. Countdowns are important because they alert everyone. This is another activity that demonstrates all three of Newton's laws of motion.
Activity Three** -** One group of cadets should prepare and launch the rocket and another group should measure the altitude the rocket reaches by estimating the angle of the rocket at its highest point form the tracking station. The angle is then put into the altitude tracker calculator and the altitude is read. Launch another rocket and reverse the roles of the groups.
Activity Four *** - This is an easier activity for building a rocket. Assemble the Goddard rocket and let it fly.

Answers to Review Questions: 1. a; 2. c; 3. b; 4. a

Summary

Review the rocket controls and be sure to do the two activities in this chapter. They are both very worthwhile and fun.

LEADER GUIDE
for
MODULE FIVE

SPACE ENVIRONMENT

Chapter 1 - Space

Learning Outcomes
After completing this chapter, you should be able to:
- Describe microgravity.
- Identify characteristics of space.
- Describe what makes up the universe.
- Define constellation.
- Define galaxy.
- Describe nebulae.
- Describe a black hole.
- Describe the Van Allen belts.
- Define cislunar space.

Important Terms:
black hole - a region in space where no radiation is emitted
cislunar space - the space between the Earth and the Moon
constellation - a grouping of stars, named after mythical figures and animals
galaxy - an enormous collection of stars arranged in a particular shape
interplanetary space - measured from the center of the Sun to the orbit of its outermost planet
interstellar space - the distance from one solar system to another
microgravity - small gravity levels or low gravity
nebulae - giant cloud of dust and gas
pulsar - pulsating star that flashes electromagnetic emissions in a set pattern
space - region beyond the Earth's atmosphere where there is very little molecular activity
star - a body of hot gases
universe - everything is part of the universe; stars, planets, galaxies, animals, plants and humans
Van Allen belts - radiation belts filled with charged particles

Activity Materials:
Activity One - Creating the Microgravity of Space - plastic drinking cup, large cookie sheet with at least one edge that doesn't have a rim, empty soda pop can, a large pail (catch basin), towels (old bath towels for cleaning spills), and a step ladder
Activity Two - The Can Throw - empty aluminum soft drink can, sharp nail, catch basin, water and towels
Activity Three - Surface Tension and Microgravity - water, liquid dish detergent, toothpicks, eyedroppers, wax paper squares (20x20 cm)

Activity Four - Rapid Crystallization - heat pack hand warmer (1 per group, sold at camping and hunting stores), water boiler (an electric kitchen hot pot can be used), styrofoam food tray (1 per group), cooler and clock
Activity Five - Astronomy in a Tube - an empty Pringles potato chip can with its opaque plastic lid, a 9”x12” sheet of black construction paper, some tape (Scotch brand), hammer, nail, straight pin and pair of scissors
Activity Six - Measuring the Brightness of the Stars - a piece of cardboard (or a file folder), and a strip of clear cellophane
Activity Seven - Analyzing Starlight - You must plan ahead. To do this activity you must purchase diffraction grating (Edmund Scientific, 101 East Glouchester Pike, Barrington, New Jersey 08007-1830 sells it). Their phone number is (609) 573-6250. Two sheets of diffraction grating measuring 6”x12” costs less than $10. These sheets will need to be cut; one sheet will make 18 two-inch squares. Twenty-five diffraction gratings mounted in 2”x2” cardboard slide mounts can be purchased for $21.95. These can be used straight from the package to build the spectroscopes for the cadets. You also need cardboard tubes (paper towels, toilet tissue, or gift wrapping tubes), scissors or hobby knives, cellophane tape, colored markers or pencils, typing or computer paper, and flashlights.
Activity Eight - The Expanding Universe - balloon, marker, twist tie or paper clip, measuring tape, paper, pencil

PRESENTATION

Attention: What is it like in space?

Motivation: Since some of us may be in space some day, we should know something about its environment.

Overview: There is a difference between space and the universe. Let’s take some time and talk about what each means.

Lesson Outline:

1. **Space is a Place**
   a. Space – Space is part of the universe, just beyond the immediate influence of Earth and its atmosphere. Space is an area where the molecules and atoms are so far apart that they don’t interact. Generally, space begins at about 80 or 90 miles from Earth. Space is characterized by a lack of oxygen, very low pressure and temperature of -273°C (absolute zero). Absolute zero is used because of lack of molecular motion in space. Also, space has very low gravity, called microgravity.
   b. Universe - Includes everything - plants, animals, humans, stars, planets and galaxies. Everything is part of the universe.

Activity One ** - Demonstrates that free fall eliminates the local effects of gravity. It creates a microgravity environment similar to what you would find in space. If you remove the sheet quickly the cup and the water both fall at the same time. **Microgravity** is defined as very low or small gravity. The Earth has a gravitational field that attracts objects and causes them to fall toward the Earth. The greater the distance between objects the less

effect of gravity. If objects decrease in distance from one another, the gravity increases. In this activity, the cookie sheet holds the cup and water in place. Once the cookie sheet is removed, the water and cup fall together.
Activity Two ** - This activity also demonstrates microgravity. While the cup is stationary, the water pours out. However, if the cup falls the water remains inside the cup the entire time it falls.
Activity Three ** - This activity studies surface tension and the fluid flows because of the differences in surface tension. When water drops fall they are spherical. Water is composed of two hydrogen atoms and one atom of oxygen, which attract each other. When the water drop hits a surface the molecules are attracted across the surface and inward. This causes the water to try to pull itself into a shape that has the least surface area possible – the sphere. Because of gravity, the drops resting on a surface will fatten out somewhat. If liquid soap is added, the soap molecules bond better than the water molecules so the water molecules spread out more. The importance of surface tension research in microgravity is that surface tension-driven flows can interfere with experiments involving fluids.
Activity Four ** - This activity investigates the growth of crystals under different temperature conditions and is best done in groups of 2-3 cadets. When the metal disk on the heat pack is clicked or snapped, crystals begin to form and heat is released. The pack can be reused by re-heating until all the crystals are dissolved. Remind cadets that the thermometer should be placed the same way for each test. Give each group one student data sheet for each test to be performed. Begin with observation of the room temperature pack first. Cadets need to be ready because complete crystallization should take less than a minute. Crystallization of the second pack will take several minutes to complete. Cadets will discover that heat packs with higher initial temperatures will take longer to crystallize. Depending on the initial temperature, crystals may resemble needles or blades. Gravity will influence their development. Crystals are solids composed of atoms, ions, or molecules arranged in orderly patterns that repeat in three dimensions. Scientists are interested in growing crystals in microgravity because gravity often interferes with the crystal-growing process, leading to defects forming in the crystal structure.

2. **More Descriptions about Space**
   a. cislunar space - is the space between the Earth and the Moon. The average distance between the Earth and its Moon is 237,087 miles. Cislunar space is not a void, but it isn't crowded either.
   b. interplanetary space - is the space measured from the Sun to the orbit of its outermost planet.
   c. galaxy - is an enormous collection of stars, and these stars are arranged in a particular shape. Our galaxy is called the Milky Way.
   d. nebulae - giant clouds of gas and dust spread throughout the galaxy.
   e. constellation - is a grouping of stars

3. **Space Environment around the Earth**
   a. ionosphere - is a part of the atmosphere divided by its electrical activity.
   b. magnetosphere - begins at about 215 miles and extends into interplanetary space. The magnetosphere is characterized by its magnetic field of force.

Activity Five * -** This activity gives cadets an idea of some of the star patterns they are seeing in the sky. Construct a tube that will then show the cadets a few of the constellations that they can see in the night sky.
Activity Six * -** This activity is designed to illustrate the magnitude of different stars. The brightness of a star is measured in magnitude. The brightest stars have the lowest magnitude, while dimmer stars have higher magnitudes. Magnitude is measured in two ways: apparent magnitude is the brightness of a star as seen from Earth while absolute magnitude is the brightness of a star as seen from a standard distance of 10 parsecs. The differences in actual brightness of stars is caused by the temperature differences between the stars. The brightest stars are those that are blue, while the faintest stars are those that are red. Star color is determined by its temperature. It is important to remember that a bright star, very far away, may seem to be just as bright as weaker, but closer, star. The sun has a magnitude of –26, six trillion times brighter than a magnitude 6 star. There are only 22 first magnitude or brighter stars.
Activity Seven * -** This activity takes some planning and costs money. To accomplish this activity, you have to order diffraction grating. It is understandable if you do not want to spend this money. This activity is here in case anyone does want to do it. This activity uses spectroscopes built by the cadets to show the difference in wavelengths of various light sources.
Activity Eight ** - This activity simply shows that when more air is added to the balloon the dots become farther apart. The dots represent stars, so as the air is expanded the stars are farther apart. Some scientists believe that the universe is still expanding.

Answers to Review Questions: 1. b; 2. a; 3. c; 4. b; 5. c

Summary

Talk about the characteristics of space, including a discussion of gravity and microgravity. Also, be sure to differentiate between space and the universe. Be sure to reinforce the learning by going back over the important terms.

Chapter 2 - Solar System

Learning Outcomes
After completing this chapter, you should be able:
- Describe our solar system.
- Define a comet.
- Explain the differences between an asteroid, meteoroid and a meteor.
- Recall the differences between solar flares, solar prominences and sunspots.

Important Terms:
solar system - the sun and the bodies that orbit around it
comet - a small icy body orbiting the sun

asteroid - a small rocky body orbiting the sun; usually found in the asteroid belt
meteoroid - clump of dust or rock orbiting the sun

meteor - a small streak of light; when a meteoroid enters the Earth's atmosphere it becomes a meteor
solar flares - short-lived high energy discharges
solar prominences - larger energy discharges that can be thousands of miles high and last for months
sunspots - darker, cooler areas of the sun

Activity Materials:
Activity One - Build a Solar Cooker - shoe box, aluminum foil, plastic wrap, a skewer and some hot dogs
Activity Two - Seeing the Moon - a dark room, a bright light source (a table lamp), a small ball (baseball), and the experimenter
Activity Three - Earth-Moon Distance - world globe (12 inches in diameter), tennis ball and string (about 20 feet long)
Activity Four - Lost on the Moon - Survival - checklist and a pencil or pen
Activity Five - Solar System Model - 33 yards of twine or rope, 4 sheets of tagboard, pencil, black marker, drawing compass, measuring tape, cellophane tape, calculator, scissors and the chart below
Activity Six - How Old Are You? - chart provided
Activity Seven - Meteoroids and Space Debris – Take two or three raw potatoes (depending on group size) and several large diameter plastic straws. Each cadet should get a chance to participate.

PRESENTATION

Attention: We have all heard the term "solar system". What does it mean?

Motivation: Why do we care what it means? Knowledge continues to pour in from all of the exploration of space. Our satellites and space probes continually transmit valuable information about our solar system to us here on Earth. Most certainly, space travel will continue and possibly increase, so it only makes sense to learn more about what is out there in space.

Overview: This chapter will take a close look at the sun, the moon and the planets of our solar system. Let's see how this lesson will continue:

Lesson Outline:

1. **The Sun**
    a. Sun facts – The sun is a star, the central star of our solar system. It provides energy for food and oxygen for us and sustains life on Earth. All of the bodies of our solar system revolve around the sun. The sun is 93 million miles from Earth and is 300,000 times as massive as Earth. The sun is composed of 90% hydrogen and 9% helium, and the temperature ranges from 4200°C to 15 million degrees C. The thin shell of the Sun's outer layer is called the photosphere. It is the part of the Sun that gives off light.

b. Solar disturbances – These occur all of the time. They last anywhere from a few seconds to years. Sunspots are darker, cooler areas of the sun. Solar flares are short-lived high-energy discharges. Solar prominences are larger and last longer. Prominences can reach thousands of miles and last for months.

Activity One ** - This is a practical and fun way to show the sun's intensity. Hot dogs work well because they are already cooked.

2. **The Moon**
   a. Moon facts – Diameter of the moon is 2155 miles (1/4 of Earth's diameter). The moon's orbit is elliptical, so it varies from 221,000 to 252,000 miles. The moon rotates on its axis in the same amount of time it takes to orbit the Earth (27 days). So, the same side of the moon always faces the Earth. How much we see of the moon is called the phases of the moon and depends on the sunlight.

Activity Two * - This is a good easy way to demonstrate the phases of the moon. Also, helps when thinking in terms of light and shadows.
Activity Three ** - This activity provides a visual demonstration of the distance between the Earth and the moon. It gives some meaning to some very large numbers concerning the Earth-moon relationship. Use 25,000 miles for the circumference of the Earth. Use 240,000 as the distance to the moon (use this average because the distance varies). When you divide the distance by the circumference you get 9.6, round down to 9.5.

b. Physical facts about the moon – It is a dry and barren place. There is no atmosphere, no water. The moon is solid rock covered with dust. There are two types of terrain - highlands and lowlands. The highlands are filled with craters surrounded by mountains. The lowlands are filled with craters flooded by molten lava. A moon day lasts 27 Earth days. Temperatures range from 250°F to -250°F. The gravitational attraction between the Earth and the moon causes movement in the Earth's tides. When the moon is closer the attraction is stronger and the tides are higher. Because the Earth rotates faster than the moon, there are two high tides a day.

c. Moon rocks – Anorthosite is the most common rock on the Moon. It is composed almost entirely of one mineral, feldspar, and is found in the highlands of the Moon. Another Moon rock is basalt. It is a dark gray rock with tiny holes from where gas has escaped.

Activity Four * -** This activity accomplishes several things; it encourages your cadets to begin thinking about the moon's atmosphere and what's important while you are visiting there. Also, they must think about the differences between the Earth's and the moon's atmospheres. It also helps their critical thinking skills and gives them a chance to compare their evaluation with NASA's official answers. This exercise can be done individually or in small groups. Small groups have the advantage of allowing the cadets to work together with others and come up with a team answer. This, of course, takes cooperation and compromise. You can talk about team building, interpersonal relations and listening skills.

Look at the actual content of their answers and their process for getting their answers. Be sure they calculate their error points and see who is the closest to NASA.
The error points are calculated by comparing each item's ranking with NASA's ranking, get the difference, then add up each difference for your total score. **Attachment 1 contains NASA's priority and the rationale for it.**

3. **The Planets**
    a. Mercury – It is the closest planet to the sun, 36 million miles. It revolves around the sun in 88 days and its temperature ranges from 800°F to - 300°F. It is a rocky, crusty surface with craters. There is no atmosphere, except for small amounts of helium and hydrogen.
    b. Venus – It is the closest planet to Earth, 67 million miles from the sun. It revolves around the sun in 225 days and its temperature reaches over 850°F. It is the only planet known to rotate in a clockwise manner. It is covered with clouds made up of water vapor and sulfuric acid. The atmosphere is 96% carbon dioxide and 4% nitrogen. Because of the thick layer of carbon dioxide and clouds, the temperature on Venus changes very little, in fact, it is the hottest planet.
    c. Earth – The Earth contains 78% nitrogen and 21% oxygen. Clouds absorb some of the sun's radiation. The Earth is covered with 67% water. It revolves around the sun in 365 days and rotates on its axis in 24 hours.
    d. Mars – Mars is the red planet, which can even be seen with the naked eye. The red color is due to rock and dust, which cover the surface of Mars. It has high iron content and is covered with deserts, mountains, craters and volcanoes. Temperatures on Mars range from -20°F to -130°F.
    e. Jupiter - It is the largest planet in our solar system. It is 11 times larger than Earth, yet rotates in about 10 hours. This fast rotation creates high winds and giant storms. Jupiter is a gas giant. The most prominent gas is hydrogen, then helium, methane and ammonia. Jupiter has a giant red spot and 16 known moons.
    f. Saturn - The rings of Saturn are its distinguishing feature. The rings are about 1 mile thick and extend about 250,000 miles from the planet. Saturn has an icy rock core surrounded by metallic hydrogen with an outer layer of hydrogen and helium. Saturn rotates in 10 hours but takes 29 years to revolve around the sun. The fast rotation creates strong winds that have reached 1,100 miles per hour. Temperatures range from 130°F to -330°F. Saturn has 18 known moons.
    g. Uranus – Uranus is 1.7 billion miles from the sun. It has a rocky core surrounded by water, ammonia and methane, both in ice and liquid form. Uranus is bluish greenish in color. It rotates in about 18 hours and revolves around the sun in 84 years. Its axis is tilted 60°, so daylight lasts 42 years, followed by 42 years of night. Temperatures stay at about -340°F.
    h. Neptune – Neptune is 3 billion miles from the sun and takes 165 Earth years to complete an orbit. Neptune rotates in 19 hours. Water, ammonia and methane surround its rocky core. Its atmosphere consists of hydrogen, helium and methane. Methane gives the planet a bluish color. Neptune is the windiest planet in the solar system. It has recorded winds of 1500 miles per hour.

   i. Pluto – It is the smallest planet and farthest from the sun. It is 4 billion miles from the sun. It has a rocky core with water and ice above the core. Its surface is made of methane frost. It has one moon, and it is half the size of the planet. Pluto has a very elongated orbit that sometimes, actually brings Pluto closer to the sun than Neptune.

4. **Other Bodies**
   a. Asteroids – Asteroids are chunks of rock that range from particles of dust to some that are a few hundred miles across. Most asteroids travel in orbit between Mars and Jupiter. This is called the asteroid belt, and scientists know the orbit of more than 15,000 asteroids. There are probably millions more out in space. The closest any asteroid has come to Earth is 100,000 miles.
   b. Comet – A comet is a giant dirty snowball composed of frozen gases and icy lumps. A comet is usually a few miles across and generally travels the outer regions of our solar system. Sometimes they get bumped off their orbit and head toward the sun. As comets move, they shed parts of themselves and leave a long tail.
   c. Meteoroids – They are tiny particles of dust and sand leftover from a comet. If a meteoroid enters the Earth's atmosphere it is called a meteor. If it actually hits the Earth it is called a meteorite.

Activity Five * -** This activity creates a model of the solar system. You need an open field, a park or a ball field for this activity. Please realize that the planet sizes are not proportionate.

Activity Six ** - This activity allows you to compare your age if you lived on the other planets. Just a little game, but it does put the concept of rotation into perspective. It also indicates a real difference between the planets.

Activity Seven ** - The actual activity requires very little time, but it affords an opportunity for a discussion about spacecraft, meteoroids and space debris. This activity shows the penetrating power of a projectile with a small mass and how it differs depending on the velocity. Even a small mass can penetrate many things if its velocity is high enough. Discussion - meteoroids strike our satellites all of the time, but most are very tiny and only cause pitting and sandblasting of the outer covering of the satellites. Of greater concern to the astronauts and space engineers is space debris. Space debris can be parts of launch vehicles, or paint chips or other equipment pieces. Most are small, but are traveling at very fast speeds. They pose significant hazards particularly to space walking astronauts. This comes into play also when and if space walking astronauts drop a nut or a bolt when they are repairing a piece of equipment.

Answers to Review Questions: 1. b; 2. a; 3. a; 4. b; 5. c

Summary

This chapter contains lots of information about the planets, the sun and the Moon, as well as, asteroids, meteoroids and comets. Be sure to review pertinent facts about all of these with your students.

DOWN ON THE MOON
RANKINGS

	ITEMS	NASA RANKING	REASON			
1	Box of matches	15	no air on the Moon so matches will not light			
2	Food concentrate	4	efficient means of supplying requirements			
3	50’ of nylon rope	6	useful in scaling cliffs or in case of injury			
4	Parachute silk	8	possible use as a sun shield			
5	Solar powered heating unit	13	not needed unless on dark side			
6	Two 45 caliber pistols	11	possible means of self propulsion			
7	One case of Pet Milk	12	bulkier duplication of energy source			
8	Stellar map	3	primary means of navigation to the Moon base			
9	Two 100-pound oxygen tanks	1	the most pressing survival requirement			
10	Self-inflating life raft	9	Carbon dioxide bottle in raft might be used as a propulsion source			
11	Magnetic compass	14	magnetic fields of Moon are not polarized so compass is useless			
12	Five gallons of water	2	replacement of tremendous liquid loss on lighted side of Moon			
13	Signal flares	10	distress signal when Moon base is sighted			
14	First aid kit containing injection needles	7	needles for medicine and vitamins fit special suit aperture			
15	Solar powered FM transceiver	5	for communication with Moon base in line of sight			
	TOTALS					

Calculate error points for the absolute difference between the NASA ranking and the individual or group ranking. Scoring: 0-26 Excellent
26-32 Good
33-45 Average
46-55 Fair
56-112 Still lost on the Moon

Attachment 1

LEADER GUIDE
for
MODULE SIX

SPACECRAFT

Chapter 1 – Unmanned Spacecraft

Learning Outcomes
After completing this chapter, you should be able to:
- Define a satellite.
- Describe an orbit.
- Define apogee and perigee.
- Identify Sputnik.
- Define a space probe.
- Describe the related parts that make up a satellite system.

Important Terms:
satellite - natural or artificial object in space that orbits the Earth
orbit - the path a satellite takes around a celestial body
apogee - the highest point of an orbit
perigee - the lowest point of an orbit
Sputnik - the first artificial satellite
COMSAT - communications satellites
INTELSAT - International Telecommunications Satellite Organization
NAVSTAR - navigation satellites
LANDSAT - satellites that locate natural resources and monitor conditions on the Earth's surface
GOES - Geostationary Operational Environmental Satellites

Activity Materials:
Activity One – Why Do Satellites Stay in Orbit? – a thread spool, string, five metal washers, nylon stocking and small rubber ball
Activity Two – Escape Velocity – cardboard trough (shaped like M), two supports of equal size (books or blocks), piece of glass (window pane), steel ball bearing and strong bar magnet

PRESENTATION

Attention: Where do the signals from our televisions come? How about the weather persons on television? Where does the information on their weather maps come? Some folks realize that satellites make these things possible. Many do not.

Motivation: This chapter will give some basic information that will help us understand satellites. We need to be aware of the exploration that is going on in space, and studying satellites well help us understand that better.

Overview: This section is about satellites, both natural and artificial. We will also discuss their orbits and the system that makes up satellites.

Lesson Outline:

1. **Satellites Types**
   a. Natural - The Moon is the Earth's only natural satellite. Its distance from the Earth varies from 221,000 to 252,000 during its elliptical orbit around the Earth. More facts about the Moon are presented in volume V, Space Environment.

   b. Artificial - Take a moment and discuss the chart on the number of satellites. In about 40 years the number of satellites in space went from 1 to over 7000. Artificial satellites are man-made and have many different missions. Some are: communications, navigation and weather.

   c. Satellites as a system - people, space environment, sub-systems and launch.
   People - This area includes the design, manufacture, launch and operation. The customers define the purpose.
   Environment - The environment includes space, gravity, radiation and space objects (planets, stars, meteors).
   Sub-systems - These are the systems that support the spacecraft in space (structure, propulsion, command and control).
   Launch - This simply refers to the satellite that is being launched in order to perform its assigned mission.

   d. Orbits - The path a satellite takes around a celestial body is called an orbit. Any object that orbits the Earth is called a satellite. Take a moment and ensure that the cadets know that planets and other objects in our solar system revolve around the sun. It is important to know that each planet's orbit is an ellipse. Because of this, each orbit has a high point (apogee) and a low point (perigee).

Activity one ** - This illustrates how the force of gravity keeps satellites in their orbit around the Earth. As you increase the speed of the ball, the washers move closer to the spool. As you slow down, the washers begin to fall away from the spool. While the ball is whirling, have someone cut the string between the washers and spool. The ball will fly away from the spool in a straight line due to its inertia. The ball is held in orbit around the spool by the string. This corresponds to the force of gravity on a satellite, which causes an inward pull. The outward pull of the ball is called centrifugal force. When these forces are equal, the ball remains in an orbit, without falling into or flying away from the spool.
Activity two ** - This activity shows a relationship between gravity and velocity. Does the steel ball have enough escape velocity to pull free of the magnet? If not, increase the speed

by tilting the trough more. To escape Earth's gravitational pull a space vehicle must be boosted to about 25,000 miles per hour. Once free it can coast through space indefinitely.

2. **Unmanned Spacecraft**
   a. COMSATs - Communication satellites began in 1958. Intelsat - International Telecommunications Satellite Organization consisting of 109 nations controlling 16 satellites. TDRSS - Tracking and Data Relay Satellite System.
   b. Natural Resources Satellites - They locate natural resources and monitor other conditions on the Earth's surface. They measure radiant energy and monitor agricultural conditions.
   c. Navigation - This began by providing Polaris missile submarines with the ability to fix accurate positions. NAVSTAR - Global Positioning System (GPS).
   d. Weather - Began in 1960. Geostationary Operational Environmental Satellites (GOES) gives pictures of Earth's surface and clouds and helps weather forecasters.
   e. Other Scientific Satellites - Explorer I - US's first satellite, launched in 1958, discovered the Van Allen Radiation Belts. Orbiting Solar Observatory (OSO) provided continuous solar observations during the 1960s and 1970s. OSO 4 gave us the first pictures of the sun. Space Probes - Satellites that either fly by, orbit or land on a celestial body, <u>other than Earth</u>. The Ranger probes were the first to take pictures of the Moon. The Mariner probes flew by Venus and Mercury. The Pioneer probes gave us pictures of Jupiter and Saturn. The Hubble Space Telescope helped us detect smaller objects more clearly.

Answers to Review Questions: 1. a; 2. b; 3. d

Summary

There are two types of satellites; natural and artificial. The Earth's only natural satellite is the Moon. There are over 7000 artificial satellites in space at this time. The artificial satellites have many missions; communications, navigation and weather are three of the most important ones.

Thinking of satellites as a system involves including the spacecraft, the people, the environment and the actual launch of the spacecraft.

Chapter 2 – Manned Spacecraft

Learning Outcomes

After completing this chapter, you should be able to:

List the manned space flight projects and their missions.
Identify the American and Russian joint manned spacecraft mission.
Describe the accomplishments of Alan Shepard and Neil Armstrong.
State specific facts about the Hubble Space Telescope.

Important Terms:
Mercury - US' first manned spaceflight project
Gemini - US' manned spaceflight project that achieved the first walk in space, and the first two-man capsule
Apollo - US' manned spaceflight project that put man on the Moon
Skylab - US' manned spaceflight project that put a laboratory into space
Apollo-Soyuz - manned spaceflight project linking American and Soviet spacecraft in space
Space Shuttle - US' Space Transportation System for transporting into space and returning to Earth

Activity Materials:
Activity One - See How the Earth Looks to an Astronaut - 16" Earth globe and a "4" Moon globe
Activity Two - Earth - Moon Distance - world globe (12 inches in diameter), tennis ball and string (about 20 feet long)
Activity Three - The Space Shuttle Glider - old file folders (1 makes 2 gliders), glue sticks or hot glue, clay stick and scissors

PRESENTATION

Attention: What significant space event happened in July of 1969? Apollo 11 landed the first man on the Moon. His name was Neil Armstrong. This was a milestone, without question, in our space program. How did we get there? What came before his historic walk?

Motivation: The events that led up to the space walk, the first manned spacecraft missions are discussed in this chapter. It is very important to know what missions took place before the landing on the Moon and what we learned from them that led to the Moon landing.

Overview: In the last chapter, we learned that there are over 7000 satellites in space. Now let's take a closer look at what some of the missions were in the manned spacecraft projects. These earlier missions led us to the Moon landing. Here's how we will precede:

Lesson Outline:

1. **Manned Spacecraft**
    a. Mercury – first manned space flight; proved humans could survive in space; flight lasted 15 minutes; Alan Shepard was onboard.
    b. Gemini – first 2-man capsule and first walk in space; first rendezvous and docking in space, convinced scientists that space flight could last for several weeks or months.
    c. Apollo – Apollo 11 put man on the Moon; Neil Armstrong on July 20, 1969.
    d. Skylab – This put a laboratory in space. The final crew spent 84 days in space.
    e. Apollo-Soyuz – This was the linkup in space of American and Soviet manned spacecraft.
    f. Space Shuttle – provides transportation into space and return back to Earth

Activity One * - This activity is meant to give the cadets an idea of how the Earth must have looked to the astronauts. The dimensions of the Earth-Moon sizes are proportional.
Activity Two **- This activity is a good way to put distances into perspective and sizes too. The ball sizes are proportional to the Earth-Moon sizes.
Activity Three ** - build your own Space Shuttle

Answers to Review Questions: 1. d 2. d 3. c

Summary

This chapter discussed the manned spacecraft that make up our space history. Emphasize to your cadets that they should remember the various projects and their missions.

Chapter 3 – Living and Working in Space

Learning Outcomes

After completing this chapter, you should be able to:

- Describe Space Station Alpha.
- Explain the differences between Mir and Skylab.
- Define Spacelab.
- Recall the significance of Salyut 1.
- Describe the living and working conditions in space.
- Describe the different space suits.

Important Terms:

Space Station Alpha - future space station, a joint venture with US, Europe, Canada, Japan and Russia
Mir - Russia's space station of the 1980s and 1990s
Salyut - Russia's first space station
Skylab - US first space station
Spacelab - European Space Agency's first space station

Activity Materials:

Activity One – Investigating Weightlessness – ping pong ball, golf ball, plastic Dixie cup, round wooden bead or a metal nut, and a piece of string
Activity Two – Keeping Cool – 2 empty coffee cans with plastic snap on lids, 2 thermometers (must be able to read a full range of temperatures from freezing to boiling), spray paint (black), floodlight and light fixture, plastic aquarium tubing (6 meters), masking tape, 2 buckets, ice, water, stopwatch or watch with a second hand, graph paper, metal punch or drill
Activity Three – How Does Motion Cause Disorientation? – swivel chair, blindfold, pencil and a friend
Activity Four – Bending Under Pressure – 2 long balloons and 3 plastic bracelets or thick rubber bands

Activity Five – Getting The Right Fit – PVC thin-wall sewer pipe (4 inches diameter), saw (crosscut or hacksaw), measuring tape or ruler (metric), duct tape, vinyl clothes-dryer hose, scissors, thick rubber gloves, and sand paper or knife

PRESENTATION

Attention: Will there be a future in space? If so, what will it be like? All indications are that there will most certainly be a future in space, not only for America, but for other countries too.

Motivation: The future of space travel looks promising. Scientists want to continue to learn more and more about the universe and beyond. This quest for knowledge coupled with the financial resources will probably ensure the continued interest in space. It is entirely possible that some of you here could one day be in space.

Overview: This chapter will discuss some of the expectations for the immediate future in space. Here's how the lesson should unfold:

Lesson Outline:

1. **Space Stations**
    a. Salyut 1 – Russia launched the first space station in 1971. Russian astronauts stayed on board for 3 weeks. Salyut 1 stayed in space for 6 months.
    b. There were 7 Salyuts; astronauts stayed aboard Salyut 7 for a 234 record days.
    c. Mir – Mir is a Russian space station. It is the largest and longest-lasting space station, and it is still there. In 1997, Mir was experiencing problems, but it is still in space. In 1987, a Russian astronaut stayed on Mir for almost a year.
    d. Skylab – This was the US' first space station. It was designed for astronauts to spend several days in space. The last crew spent 84 days in space.

2. **Living in Space**
    a. Skylab – Primarily the astronauts conducted experiments concerning living and working in space.
    b. Spacelab – Spacelab was designed by the European Space Agency. It conducted similar experiments from inside the Space Shuttle. However, it was never in space more than 30 days.
    d. Alpha – Alpha is the future space station. It is a joint US, Europe, Canada, Japan and Russia venture. Alpha is designed to be a permanent space station.
    e. General comments - Space stations contain food, water and oxygen for sustaining life. Space stations can use any of three types of life-support systems; (1) closed - a total recycling between living things and their environment; (2) semi-closed - some of the items for life support were recycled; (3) open - food, water and oxygen are placed on board for each flight.

3. **Spacesuits**
   a. Early spacesuits – These were really high-altitude pressure suits.
   b. Gemini spacesuits – These were very light weight suits.
   c. Apollo spacesuits – These were heavier suits with an oxygen supply in a backpack.
   d. Space Shuttle – This is called an Extravehicular Mobility Unit (EMU). It is used for going outside the shuttle. The EMU is only worn when going outside. When inside, the astronauts wear comfortable clothing - regular shirts and slacks.

Activity One ** - This is a good way to discuss gravity and weightlessness and how it applies to space. When you drop the ping pong and golf ball at the same time from the same height, they will reach the floor at the same time. Mention how Galileo discovered this back in the 1400s. Supposedly standing on the Lending Tower of Pisa, he demonstrated this several times with various objects. This is called free fall. In the next part of the experiment, the bead and string will fall at the same rate as the cup and will hang just above the cup until the cup hits the floor. The bead and string will then fall into the cup. When discussing with cadets, allow them to figure out that the bead and the cup are falling at the same rate.
Activity Two * -** This activity concerns spacesuit design. It is a challenge to maintain a comfortable temperature inside the suit since the temperatures in space are so extreme. This activity functions as a demonstration of a liquid cooling unit inside a spacesuit showing how temperatures moderate body heat. Astronauts out on extravehicular activity are in a constant state of exertion. Body heat released from this exertion can quickly build up inside a space suit, leading to heat exhaustion. Body heat is controlled by a liquid cooling-garment made from stretchable spandex fabric and laced with small diameter plastic tubes that carry chilled water. The water is circulated around the body. Excess body heat is absorbed into the water and carried away to the suit's backpack, where it runs along a porous metal plate that permits some of it to escape into outer space. The water instantly freezes on the outside of the plate and seals the pores. More water circulates along the back of the plate. Heat in the water is conducted through the metal to melt the ice directly into water vapor. During the process, the circulating water is chilled. The process of freezing and thawing continues constantly at a rate determined by the heat output of the astronaut. This activity demonstrates how chilled water can keep a metal can from heating up even when exposed to the strong light of a floodlight.

Activity Three ** - This activity shows how motion causes disorientation. As the chair swivels, the blindfolded person will point the pencil sideways, pointing in the direction opposite from the way the chair is moving. The blindfolded person will not be aware that the pencil is pointing sideways. He or she will think it is pointing straight up. When you swivel the chair in the opposite direction, the pencil will again be pointing in the opposite direction. Motion does cause disorientation and sight is one of our senses that helps us stay oriented.

Activity Four * - This activity indicates the mobility of a spacesuit arm. Maintaining proper pressure inside a spacesuit is essential for survival. However, pressure produces problems. An inflated spacesuit is hard to bend. Designers have learned to strategically place breaking points at appropriate places to make the suit bend more. In this activity, the rings serve as the breaking points. These rings create joints. Further spacesuit research has shown that built-in ribs like a clothes dryer or vacuum cleaner hose promote easier bending.

Answers to Review Questions: 1. c; 2. d; 3. b

Summary

This chapter dealt with the immediate future in space. It concentrated on space stations, living in space and spacesuits. Space exploration will continue in the future and space travel will likely become even more commonplace. With that in mind, it makes sense to learn more about what is destined to be a large part of our future lives.

AEROSPACE DIMENSIONS

MATERIALS LIST

The majority of the materials on this list are items that can be found around the house. All items are easily obtainable at a local hardware store or large store such as Wal-Mart.

MODULE ONE – INTRODUCTION TO FLIGHT

Chapter 1 - Flight

ACTIVITY ONE --- THE LUNG-POWER WIND TUNNEL

For each person:

one sheet of 8-1/2" X 11" paper

ACTIVITY TWO --- IS BERNOULLI'S LAW WORTH TWO CENTS?

For each person or group:

one sheet of 8-1/2" X 11" paper
cellophane tape
two pennies
hand-held hair dryer
a table

ACTIVITY THREE --- THE SODA STRAW THREE AXIS DEMONSTRATOR

For each person:

Three soda straws
One hand held, single hole paper punch

ACTIVITY FOUR --- LET'S BUILD A PAPAR FLYING MACHINE

For each person:

one sheet of 8-1/2" X 11" paper
scissors [may be shared]

ACTIVITY FIVE --- BUILD THE SR-71 BLACKBIRD

For each person:

1 ¾" outside diameter pipe foam tubing cut to a length of 14 inches
foam meat tray
#64 rubber band
nylon cable tie
hot glue gun

Chapter 2 – To Fly by the Lifting Power of Air

ACTIVITY ONE --- BUILD AN AIR FORCE ACADEMY GLIDER

For each person::

one ¼” foam meat tray
a photocopy of the Academy Glider templates from the book [two pages]
paint stirring stick
medium grit sandpaper
cellophane tape
hobby knife or X-Acto knife [may be shared]
hot glue gun [may be shared]

MODULE TWO – AIRCRAFT SYSTEMS & AIRPORTS

Chapter 1 – Aircraft Systems

ACTIVITY ONE --- GYROSCOPES: HAVING FUN WITH SCIENCE

For each person or group:

one gyroscope

ACTIVITY TWO --- THE INSTRUMENT PANEL SHOOTOUT!

For each person:

Aircraft Systems and Airports textbook
one sheet of 8-1/2” X 11” paper

Chapter 2 - Airports

ACTIVITY THREE --- THE FINAL APPROACH!

For each person:

toy plastic airplane with fixed landing gear
two eye screws
30’ to 40 feet of fish line
one stick, 18” to 24” in length masking tape to lay out a “runway” on the floor OR a cardboard “runway” a chair

Prior to the activity:

obtain a plastic toy airplane with fixed landing gear
fit the plane with two eye screws so it hangs straight and level on a fish line
tie one end of the fish line to a place high up in the room
tie the other end around the stick
prepare the “runway”

ACTIVITY FOUR --- HEY YOU, BRAVO – OSCAR – BRAVO!

No special materials needed

ACTIVITY FIVE --- SECTIONAL CHART SHOOTOUT!

For each person:

Aircraft Systems and Airports textbook

For the group:

A transparency of the Sectional Chart in the *Aircraft Systems and Airports* textbook

MODULE THREE – AIR ENVIRONMENT

Chapter 1 – Air Circulation

ACTIVITY ONE --- ABSORBING HEAT

For the group:

2 tin cans
2 thermometers
soil, water and sunlight

ACTIVITY TWO --- WARM AIR FEELING

For the group:

Paper, pencil (wooden, with eraser), scissors, metal thimble, needle, spool (sewing thread) and table lamp

ACTIVITY THREE --- CORIOLIS FORCE

For the group:

a globe and chalk

ACTIVITY FOUR --- GLOBAL WINDS

For the group:

illustration from activities section
pencil and colored pencils or markers

Chapter 2 – Weather Elements

ACTIVITY ONE --- WIND CURRENTS

For the group:

electric fan, stack of different sized books and a strip of tissue paper

ACTIVITY TWO --- WIND GAUGE

For the group:

clear, plastic drinking straw, small styrofoam ball, two pins, piece of cardboard (about 3x12 inches), transparent tape and exacto knife or scissors

ACTIVITY THREE --- CONVERT TEMPERATURES

For the group:

problems supplied in activity section

ACTIVITY FOUR --- THERMOMETER

For the group:

clear glass bottle (pint or quart), cork or stopper with one hole, plastic drinking straw, 3x5" card, pencil, water, food coloring, candle, matches, transparent tape, oil and a medicine dropper

ACTIVITY FIVE --- CRICKET THERMOMETER

For the group:

chirping cricket, a watch with a second hand and a warm day

ACTIVITY SIX --- HOW TO MAKE A BAROMETER

For the group:

Clear glass or jar, a bowl, four paper clips, water and a grease pencil

ACTIVITY SEVEN --- MATCH THE INSTRUMENT WITH WHAT IF MEASURES

For the group:

matching problems on page 17

CHAPTER 3 – Moisture and Clouds

ACTIVITY ONE --- COMFORT AND HUMIDITY

For the group:

plastic bag or empty bread wrapper, tape and water at room temperature

ACTIVITY TWO --- DEW POINT

For the group:

tin can, thermometer, tablespoon, ice cubes, paper towel, bowl, cool water and salt

ACTIVITY THREE --- MAKING FOG

For the group:

clear glass jar, tea strainer, ice cubes and hot water

ACTIVITY FOUR --- CLOUD IN A BOTTLE

For the group:

glass jug with a small mouth and a match or candle

ACTIVITY FIVE --- MAKING A RAIN GAUGE

For the group:

a 1-pound coffee can, olive jar, ruler, marking pen, water, funnel and a watch

Chapter 4 – Weather Systems and Changes

ACTIVITY ONE --- AIR MASSES

For each person:

Air Environment textbook

ACTIVITY TWO --- IDENTIFYING FRONTS

For each person:

Air Environment textbook

ACTIVITY THREE --- FRONTS ON MAPS

For each person:

Air Environment textbook

ACTIVITY FOUR --- DISTANCE TO A STORM

For each person or group:

stopwatch or clock with a second hand
thunderstorm

MODULE FOUR - ROCKETS

Chapter 1 – History of Rockets

ACTIVITY ONE --- THE HERO ENGINE

For the group:

Empty soda can, medium-size nail, string, bucket or tub of water and a hammer

ACTIVITY TWO --- MAKING A PAPER ROCKET

For the group:

Paper, cellophane tape, scissors, sharpened pencil and a straw (slightly thinner than the pencil)

ACTIVITY THREE --- BALLOON STAGING

For the group:

Two long balloons, nylon monofilament fishing line (any weight), Two plastic straws (milkshake size), styrofoam coffee cup, masking Tape, scissors and two spring clothespins

CHAPTER 2 – ROCKET PRINCIPLES

ACTIVITY ONE --- BALLOON ROCKET

For the group:

a balloon

ACTIVITY TWO --- ROCKET RACER

For the group:

four pins, styrofoam meat trays, masking tape, flexible straw, scissors, drawing compass, marker pen, small round party balloon, ruler, student sheets (one set per group), 10-meter tape measure or other measuring markers for track (one for whole class)

ACTIVITY THREE --- LAW OF INERTIA

For the group:

stack of checkers

ACTIVITY FOUR --- TWO BALLOONS

For the group:

two balloons, inflated and tied

ACTIVITY FIVE --- ROLLER SKATES AND JUG

For the group:

roller skates and plastic jug of water

ACTIVITY SIX --- Antacid Tablet Race

For the group:

effervescent antacid tablets (4 per group), two Beakers (or glass or plastic jars), tweezers and forceps, scrap paper, watch or clock with second hand, thermometer, eye protection and water (warm and cold)

ACTIVITY SEVEN --- Newton Car

For the group:

wooden block about 10x20x2.5 cm, 3 3-inch #10 wind screw (round pencils or short lengths of similar dowel , plastic film canister, assorted materials filling canister (washers, nut, etc) 3 rubber bands, cotton string, matches or lighter, eye protection for each student, metric beam balance (primer balance), vice, screwdriver and a meter stick

Chapter 3 – Rocket Systems and Controls

ACTIVITY ONE – 3-2-1 POP

For the group:

heavy paper (60-110 index stock or construction paper), plastic 35 mm canister, student sheets, cellophane tape, scissors, effervescing antacid tablet, paper towels, water and eye protection for all participants

ACTIVITY TWO --- BOTTLE ROCKET AND BOTTLE ROCKET LAUNCHER

For each bottle rocket:

2-liter plastic soft drink bottle

poster board
heavy tape [such as strapping tape or duct tape]
low temperature glue gun [may be shared]
modeling clay [may be shared]
scissors [may be shared]
decals, stickers, and marking pens [may be shared]
safety glasses for all participants
bottle rocket launcher [see below]

For the bottle rocket launcher:

four 5” corner irons with twelve ¾” wood screws
one 5” mounting plate
two 6” spikes
two 10” spikes OR metal tent stakes
two 5” X ¼” carriage bolts with six ¼” nuts
one 3” eyebolt with nuts and washers
four ¾” diameter washers to fit bolts
one #3 rubber stopper with a single hole

ACTIVITY TWO --- BOTTLE ROCKET AND BOTTLE ROCKET LAUNCHER
[CONTINUED]

one snap-in tubeless tire valve
one 12” X 18” X ¾” wood board
one 2-liter soft drink bottle
twelve feet of ¼” cord, pencil,
electric drill and bits, including a $^{3}/_{8}$” bit
screwdriver, pliers, OR
open-end wrench to fit nuts,
vise

ACTIVITY THREE --- ALTITUDE TRACKING

For each person:

altitude tracker pattern
altitude calculator pattern
thread or lightweight string
scrap cardboard or poster board
small washer
brass paper fastener
scissors [may be shared]
glue [may be shared]
cellophane tape [may be shared]
hobby knife or X-Acto knife [may be shared]
cutting surface OR cardboard to protect tabletop
meter stick OR metric
rocket
launcher

ACTIVITY FOUR – GODDARD ROCKET

For each person:

13/4” outside pipe foam tubing cut to 14”
foam meat tray
#64 rubber band
nylon cable tie
hot glue gun

MODULE FIVE – SPACE ENVIRONMENT

Chapter 1 – SPACE

ACTIVITY ONE – CREATING THE MICROGRAVITY OF SPACE

For the group:

plastic-drinking cup, large cookie sheet with at least one edge that doesn’t have a rim, empty soda pop can, a large pail (catch basin), towels (old bath towels for cleaning spills), a step ladder

ACTIVITY TWO --- THE CAN THROW

For the group:

empty aluminum soft drink can, sharp nail, catch basin, water and towels

ACTIVITY THREE --- SURFACE TENSION AND MICROGRAVITY

For the group:

water, liquid dish detergent, toothpicks, eyedroppers, wax paper squares (20 x 20 cm)

ACTIVITY FOUR --- RAPID CRYSTALLIZATION

For the group:

heat pack hand warmer (1 per group, sold at camping and hunting stores), water boiler (an electric kitchen hot pot can be used), styrofoam food tray (1 per group), metric thermometer (1 per group), tong, observation and data table (1per group), cooler and clock

ACTIVITY FIVE --- ASTRONOMY IN A TUBE

For the group:

an empty Pringles potato chip can with its opaque plastic lid
a 9”x12” sheet of black construction paper
some tape (Scotch brand),
hammer, nail, straight pin, and pair of scissors

ACTIVITY SIX --- MEASURING THE BRIGHTNESS OF THE STARS

For the group:

each participant needs a piece of cardboard (or a file folder),
a strip of clear cellophane

ACTIVITY SEVEN --- ANALYZING STARLIGHT

For the group:

You must plan ahead. To do this activity you must purchase diffraction grating. Edmund Scientific, 101 East Glouchester Pike, Barrington, New Jersey 08007-1830 sells it). Their phone number is (609) 573-6250. Two sheets of diffraction grating measuring 6"x12" costs less than $10. These sheets will need to be cut; one sheet will make 18 two-inch squares. Twenty-five diffraction gratings mounted in 2"x2" cardboard slide mounts can be purchased for $21.95. These can be used straight from the package to build the spectroscopes for the cadets. You also need cardboard tubes (paper towels, toilet tissue, or gift wrapping tubes), scissors or hobby knives, cellophane tape, colored markers or pencils, typing or computer paper, flashlights.

ACTIVITY EIGHT --- THE EXPANDING UNIVERSE

For the group:

balloon, marker, twist tie or paper clip,
measuring tape, paper, pencil

Chapter 2 – Solar System

ACTIVITY ONE --- BUILD A SOLAR COOKER

For each person:

one shoebox
aluminum foil
plastic wrap
a skewer
hot dogs

ACTIVITY TWO --- SEEING THE MOON

FOR THE GROUP:

a dark room
a bright light source
a small ball, such as a baseball
the experimenter

ACTIVITY THREE --- EARTH – MOON DISTANCE

For the group:

world globe -- twelve inch diameter
tennis ball
string -- about twenty feet

ACTIVITY FOUR --- LOST OF THE MOON -- SURVIVAL

For each person :

checklist from *Space Environment* textbook
pen or pencil

ACTIVITY FIVE --- SOLAR SYSTEM MODEL

To complete one model:

thirty-three yards of twine or rope
four sheets of tagboard
pencil
black marker
drawing compass
measuring tape
cellophane tape
calculator
scissors
chart provided in *Space Environment* textbook

ACTIVITY SIX – HOW OLD ARE YOU?

For the group:

chart provided in *Space Environment* textbook

ACTIVITY SEVEN --- METEOROIDS AND SPACE DEBRIS

For each group:

two or three raw potatoes
several large diameter plastic straws

MODULE SIX – SPACECRAFT

Chapter 1 – Unmanned Spacecraft

ACTIVITY ONE --- WHY DO SATELLITES STAY IN ORBIT?

For each group:

a thread spool, string, and five metal washers,
nylon stocking and a small rubber ball

ACTIVITY TWO --- ESCAPE VELOCITY

For each group:

cardboard trough (shaped like an M), two supports of equal size (books or blocks), piece of glass (windowpane), steel ball bearing and a strong bar magnet

Chapter 2 – Manned Spacecraft

ACTIVITY ONE --- SEE HOW THE EARTH LOOKS TO AN ASTRONAUT

For each group:

16” Earth globe and a 4” Moon globe

ACTIVITY TWO --- EARTH-MOON DISTANCE

For each group:

world globe (12 inches in diameter),
tennis ball,
string (about 20 feet long)

ACTIVITY THREE --- THE SPACE SHUTTLE GLIDER

For each group:

old file folders (1 makes 2 gliders),
glue sticks or hot glue
scissors

Chapter 3 – Living and Working in Space

ACTIVITY ONE --- INVESTIGATING WEIGHTLESSNESS

For each person or group:

one ping pong ball, one golf ball,
one plastic Dixie cup
one round wooden bead or metal nut
a piece of string

ACTIVITY TWO --- KEEPING COOL

For each group:

two empty coffee cans with plastic snap on lids
two thermometers capable of reading ranges from freezing to boiling
black spray paint
floodlight and light fixture
six meters of plastic aquarium tubing
masking tape, two buckets, ice, water,
stopwatch or clock with a second hand,
graph paper
metal punch or drill

ACTIVITY THREE --- HOW DOES MOTION CAUSE DISORIENTATION?

For each group:

swivel chair
blindfold
pencil, one friend

ACTIVITY FOUR --- BENDING UNDER PRESSURE

For each group:

2 long balloons, 3 plastic bracelets or thick rubber bands